Experimental Design of Class Characteristic Factors against Energy Expenditure, Mental Fatigue and Performance Using Anova Method

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ABSTRACT

College which is highest level formal education has an academic activities and non-academic. Academic activity which is lectures activity is a mental activity because students are required to think and not doing physical activity. Lecturing activities are generally associated with class characteristic factors which included a courses difficulty factor, lecturer characteristics, and weight of credit. These three things are coexist, and researcher wanted to know whether those three things can affect the energy expenditure, the level of mental fatigue, and performance of the students.

Data processing was performed using ANOVA method (Analysis Of Variance), normality test with Anderson-Darling test, and homogeneity test by Levene's test. The objective of this paper is to investigate the effect of different of course difficulty levels, lecturer characteristics, and the weight of credit against energy expenditure, mental fatigue level, and performance level. Particular focus was placed to identify which combinations of lecture characteristic factors that generate the most excellent energy expenditure, mental fatigue, and performance in conducting lecture activities.

Keywords: Energy Expenditure, Mental Fatigue, Performance, Class Characteristics, and Experimental Design

1. INTRODUCTION

College is the stage where the students undergo formal education at the highest level. College world is a process of academic activities such as a lectures activity, and non-academic activities. Lectures is a mental activity, not physical activity because students are required to think and not doing physical activity. Lecturing activities are generally associated with the class characteristic factors which included a factor of the level of courses difficulty, lecturer characteristic, and the weight of credit.

Although currently most colleges have really paid attention to student facilities such as air conditioning, comfortable desk chair, and so on, but there are still many complaints from students who feel tired after attending a lectures. It can be known through the preliminary research that has been conducted to seven people in two different classes, the first is class with hard difficulty course level, very conducive lecturer, 3 credits; and the second is class with medium difficulty course level, a quite conducive lecturer, 2 credits. In this preliminary research, Math Workout application was used to assess the decrease of performance, the obtained results in this application is the time value in second which is a smaller better scale, and assessment sheets Rating of Perceived Exertion - Borg Scale was used to assess the degree of mental fatigue, where the value scale is also smaller better. The preliminary research that has been done, was used for examine whether there are possible factors can affect the student's energy expenditure, mental fatigue, and performance.

Table 1. Preliminary Research Recapitulation

		Performance (Math Workout-Smaller Better)		Mental Fatigue (RPE Borgscale-Smaller Better)	
		Before class	After class	Before class	After class
Average of 7 students	Difficult course, highly condusive lecturer, 3 credits	29,659	36,277	7,857	9,286
Average of 7 students	Easy course, quite condusive lecturer, 2 credits	32,748	32,257	7,167	7,500

Based on the previous explanations and preliminary research that has been done, the problem discussed in this research is whether there is any influence of class characteristic factors which is included the difficulty level of course, characteristics of the lecturer, and the weight of credit against the level of mental fatigue, level of performance, and energy expenditure?

From that summary of the problem, it can be concluded the purposes of this research are as follows:

1. Identify the effect of different of course difficulty levels, lecturer characteristics, and the weight of credit against energy expenditure, mental fatigue level, and performance level.

2. Analyzing which combinations of lecture characteristic factors that generate the most excellent energy expenditure, mental fatigue, and performance in conducting lecture activities.

2. METHODOLOGY

The research methodology is a series of systematic steps that required in conducting research. In general, this research is divided into several stages, those are: Preparation of Research, Data Collection, Data Processing, Data Analysis, and Withdrawal Conclusions and Recommendations. Research preparation that conducted by researchers are seeing the appearance complaints of the mental fatigue and performance reduction of students after attending class, it encourage researchers to identify what class characteristics factors that can influence the performance, mental fatigue, and energy expenditure of college students during the class.

Stages of data collection will begin with the determination of the factors and response variables.

Factor Variables Determination

Factors in this research are class characteristics factors. According to several sources and explanations from the expert lecturers, there are several factors included in the class characteristics, those are: the difficulty level of course, the type of lecturer characteristics, and the weight of credit units. Course is a set of plans and arrangements regarding the content and study materials and lessons are used as guidelines for the implementation of learning and teaching / lecture activity in college. According to Damar Kristianto (2011), group classify of the courses difficulty level factor is based on the academic condition of the student / in this case the grade point average (subjective). And the objectively aspect that underlying classification of the course difficulty, includes how many supporting tasks, the amount of material being taught, and the number of prerequisite courses. Determining the level of courses difficulty on Atma Jaya Jakarta industrial engineering courses assessed with a questionnaire containing the objective and the subjective aspect, which the results are used to classify the courses are difficult or easy.

Lecturer is the main executor figure in carrying out the mission of Tri Dharma College, which are educating and teaching, researching and community servicing. Lecturer role is principal key to the success and the great quality of a college, so the conducive lecturer are required by a college in order to achieve every principal mission that was planned, because conducive lecturer is at the optimal quadrant on the willingness and abilities aspects (Rizki Hakiki, 2009). Classification of the lecturer characteristics type in teaching method can be divided into very conducive lecturer and quite conducive lecturer. Wherein the characteristic that more conducive lecturer should decreasingly authoritarian, good and clear in presenting the lecture material, able to create a pleasant learning environment (Rizki Hakiki, 2009). Determination of the characteristics lecturer type assessed through the results of a questionnaire containing those aspects.

Table 2. Factors and Extent Factor

Factor	Extent Factor
Difficulty of Course	Difficult
	Easy
Weight of Credit	2 Credit
	3 Credit
Lecturer Characteristics	Highly Condusive
	Quite Condusive

In this research there are three responses that were observed, that are energy expenditure, performance level, and the level of mental fatigue. Energy expenditure is the energy that used by a person in performing an activity over a specified period, and a multiplication between the power and the operating time (Volp Pinheiro, 2011).

Response Variables Determination

In this research, there are three responses variables that have been determined, that are energy expenditure, mental fatigue, and performance. Data collection energy expenditure of student can be measured using Actiheart and Polar FT 60 which have an output in units of calories. The follows figure of energy expenditure measuring tool.

Figure 1. Actiheart

According Wignjosoebroto (2000), mental fatigue caused by psychological factors. Mental fatigue is associated with depression,

nervousness, and the other psychosocial conditions. Mental fatigue is exacerbated by stress, as example workers have psychiatric problems unresolved can cause psychological stress. In this research, mental fatigue of student was assessed using the rating of perceived exertion (RPE) Borgscale. RPE Borgscale sheet assessment consists of 6-20 interval scale that each scale has a mental fatigue significance level. The following figure is Borgscale assessment sheets.

Figure 2. RPE *Borg's Scale* Sheet Assessment

        Performance by Cascio (1998) is a person's accomplishments and achievements in the tasks that have been imposed on him. In this research, data collection performance of the college students was measured using a set of questions that are not too difficult and not too easy, and does not require special skills to do it by math workout application which have an output in units of time.

        The next step was determining the mathematical model that used for a factorial design in this research. This research has three factors, those are: the difficulty of course which is represented with S with the extent factors i: 1, 2; the weight of credit which is represented with C with the extent factor j: 1, 2; characteristic of the lecturer which is represented with K with the extent factor k: 1, 2. Stages of experimental research conducted with using perfect randomized designs for each treatments combination for each n observations.

Mathematical model in this research is as follows:

$$y_{ijkl} = \mu + S_i + C_j + K_k + (SC)_{ij} + (SK)_{ik} + (CK)_{jk} + (SCK)_{ijk} + \varepsilon_{ijkl}$$

$$i = 1,2; \ j = 1,2; k = 1,2; \ \text{and } l = 1,2,3,4,5$$

Explanation:

y_{ijkl} : The response variable that occurs due to the mutual influence of i extent factor of S factor, j extent factor of C factor, k extent factor of K factor for observation l.

μ : The actual average (a constant value)

S_i : The effect of i extent factor of S factor difficulty of course toward the y response variable.

C_j : The effect of j extent factor of C factor weight of credits toward the y response variable.

K_k : The effect of k extent factor of K factor lecturer characteristic toward the y response variable.

$(SC)_{ij}$: The interaction effect of i extent factor of S factor difficulty of course and j extent factor of C factor weight of credits toward the y response variable.

$(SK)_{ik}$: The interaction effect of i extent factor of S factor difficulty of course and k extent factor of K factor lecturer characteristic toward the y response variable.

$(CK)_{jk}$: The interaction effect of j extent factor of C factor weight of credits and k extent factor of K factor lecturer characteristic toward the y response variable.

$(SCK)_{ijk}$: The interaction effect of i extent factor of S factor difficulty of course and j extent factor of C factor weight of credits and k extent factor of K factor lecturer characteristic toward the y response variable.

ε_{ijkl} : Effect of ijk treatment combination toward l experimental unit.

        In this research use the fixed Model due to the treatments which is used in this research comes from a finite population and the selection of treatment is determined directly by researchers, when the extents for each factor fix the number and all are used in experiments it can be referred to as a fixed model (Sudjana, 1995). After a determination of mathematical model of this research, then formulated the initial hypothesis and rival hypotheses for the ANOVA effect test:

The initial hypothesis of the influence of main factors, the course difficulty factor, weight of credits factor, and, lecturer characteristic factor:

- $H_0 : S_i = 0$ {There is no effect of the S factor courses difficulty toward y response variable} with $i = 1,2$
- $H_0 : C_j = 0$ {There is no effect of the C factor weight of credit toward y response variable} with $j = 1,2$
- $H_0 : K_k = 0$ {There is no effect of the K factors lecturer characteristics toward y response variable} with $k = 1,2$

The initial hypothesis of the interaction of course difficulty level factor, weight of credits factor, and lecturer characteristic factor:

- $H_0 : SC_{ij} = 0$ {There is no effect of the S factor course difficulty level and C factor weight of credits toward the y response variable} with $i = 1,2$ and $j = 1,2$
- $H_0 : SK_{ik} = 0$ {There is no effect of the S factor course difficulty level and K factor lecturer characteristic toward the y response variable} with $i = 1,2$ and $j = 1,2$
- $H_0 : CK_{jk} = 0$ {There is an effect of the C factor weight of credits and K factor lecturer characteristic toward the y response variable} with $i = 1,2$ and $j = 1,2$
- $H_0 : SCK_{ijk} = 0$ {There is an effect of the S factor course difficulty level, C factor weight of credits and K factor lecturer characteristic toward the y response variable} with $i = 1,2$ $j=1,2$ and $k = 1,2$

The rival hypothesis of the influence of main factors, the course difficulty factor, weight of credits factor, and, lecturer characteristic factor:

- $H_1 : S_i \neq 0$ {There is an effect of the S factor courses difficulty toward y response variable} with $i = 1,2$
- $H_1 : C_j \neq 0$ {There is an effect of the C factor weight of credit toward y response variable} with $j = 1,2$
- $H_1 : K_k \neq 0$ {There is an effect of the K factors lecturer characteristics toward y response variable} with $k = 1,2$

The rival hypothesis of the interaction of course difficulty level factor, weight of credits factor, and lecturer characteristic factor:

- $H_1 : SC_{ij} \neq 0$ {There is an effect of the S factor course difficulty level and C factor weight of credits toward the y response variable} with $i = 1,2$ and $j = 1,2$
- $H_1 : SK_{ik} \neq 0$ {There is an effect of the S factor course difficulty level and K factor lecturer characteristic toward the y response variable} with $i = 1,2$ and $j = 1,2$
- $H_1 : CK_{jk} \neq 0$ {There is an effect of the C factor weight of credits and K factor lecturer characteristic toward the y response variable} with $i = 1,2$ and $j = 1,2$
- $H_1 : SCK_{ijk} \neq 0$ {There is an effect of the S factor course difficulty level, C factor weight of credits and K factor lecturer characteristic toward the y response variable} with $i = 1,2$ $j=1,2$ and $k = 1,2$

Data processing with the experimental design has been conducted by examining three independent variables, the difficulty level of the course, the weight of credits, and the lecturer characteristics against three dependent variables, those are energy expenditure, the level of mental fatigue, and level of performance.

Furthermore the data that has been obtained could be used to calculate average score of overall energy expenditure, mental fatigue, and performance in each class characteristic factors combination. So we can determine what class combination (lecturer characteristic factor, the course difficulty level factor, and the weight of credits factor) that generate the most excellent performance. The data calculation should be changed into higher better value, due to the energy expenditure was measured using Actiheart and Polar FT60 which has a caloric unit where the results generated are lower better. As for mental fatigue level was measured with assessment sheet of ratings perceived exertion Borg scale where the higher of mental fatigue level is getting worse, while to the performance level is measured using Math Workout application that generates output time of second, which is also the lower better scale.

Furthermore all data was changed into a scale of 0-1, after that all data was averaged. The result shows the class with a quite conducive lecturer, easy course, and weighs 2 credits generate the highest performance.

3. RESULT

Data that have been obtained are processed with the ANOVA method for each response variable, and normality test is conducted using Anderson-Darling test with Mintab 15 software, and homogeneity test using Levene's test in SPSS software. The results of the independent variables effect of the dependent variables are obtained from the manual calculation and SPSS software calculation. Recapitulation of data processing results can be seen in the following table.

Table 3. Results of Student's Energy Expenditure, Mental Fatigue, and Performance Research

Dependent Variable	Independent Variable	Normality Test		Homogeneity Test		ANOVA Test	
		P-Value	Information	Sig.	Informatio	F	Information
Energy Expenditure	(S) Difficulty of Course	0.707	Normal Distribution	0.504	Equal Variance / Homogen	5.143	Affect Significantly
	(C) Weight of Credit					0.087	Not Affect
	(K) Lecturer Characteristics					5.67	Affect Significantly
	SC Interaction					0.711	Not Affect
	SK Interaction					8.24	Affect Significantly
	CK Interaction					2.104	Not Affect
	SCK Interaction					3.576	Not Affect
Mental Fatigue	(S) Difficulty of Course	0.055	Normal Distribution	0.464	Equal Variance / Homogen	0.76	Not Affect
	(C) Weight of Credit					4.38	Affect Significantly
	(K) Lecturer Characteristics					10.981	Affect Significantly
	SC Interaction					4.38	Affect Significantly
	SK Interaction					1.49	Not Affect
	CK Interaction					0	Not Affect
	SCK Interaction					0.487	Not Affect
Performance	(S) Difficulty of Course	0.324	Normal Distribution	0.733	Equal Variance / Homogen	5.825	Affect Significantly
	(C) Weight of Credit					0.004	Not Affect
	(K) Lecturer Characteristics					11.026	Affect Significantly
	SC Interaction					4.368	Affect Significantly
	SK Interaction					1.066	Not Affect
	CK Interaction					0.706	Not Affect
	SCK Interaction					1.992	Not Affect

Based on table 3, it can be seen what the independent variables (class characteristic factors) that influence the dependent variables (level of mental fatigue, level of performance, and energy expenditure).

The following recapitulation table and chart are an average of overall energy expenditure, mental fatigue, and performance for each factors combination (lecturer characteristic factor, course difficulty, and weight of credit).

Table 4. The Average Score of Overall Energy Expenditure, Mental Fatigue, and Performance of Students

| Lecturer Characteristics	Difficulty of Course	Weight of Credit	Energy Expenditure	Mental Fatigue	Performance	Average
Highly Condusive	Difficult	2	0,5784	0,444	0,267	0,4298
		3	0,5838	0,4	0,528	0,5041
	Easy	2	0,4876	0,667	0,691	0,6152
		3	0,6081	0,444	0,525	0,5259
Quite Condusive	Difficult	2	0,5270	0,689	0,670	0,6288
		3	0,5811	0,733	0,657	0,6571
	Easy	2	0,9584	0,844	0,796	0,8664
		3	0,7130	0,533	0,700	0,6487
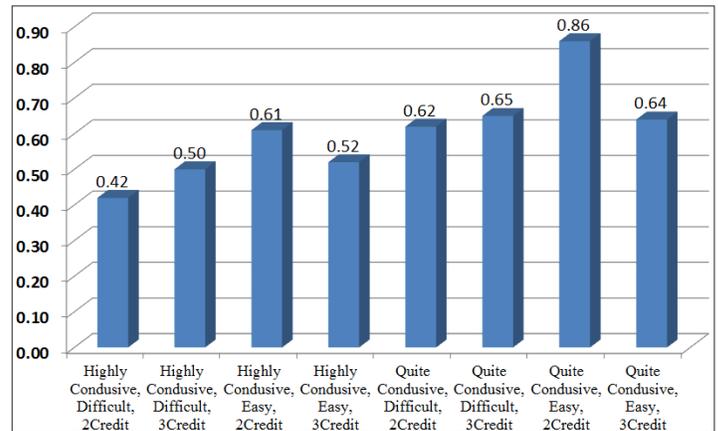
Figure 3. Average of Energy Expenditure, Mental Fatigue, and Performance in Each Class Characteristic Combination Chart

Based on the overall score calculation of the energy expenditure, level of mental fatigue, and performance that have been done, it can be concluded that a class with the optimal energy expenditure, level of mental fatigue, and performance is on a combination of quite conducive lecturer characteristic, easy courses, and weighs of 2credits.

4. DISCUSSIONS

Differences in energy expenditure, mental fatigue level, and the level of performance which influenced by class characteristics factors that consisting of the lecturer characteristic, the difficulty level of the course, and the weight of credits are presented in these following chart. There are three charts of response variables, those are energy expenditure chart, level of mental fatigue chart, and level of performance chart.
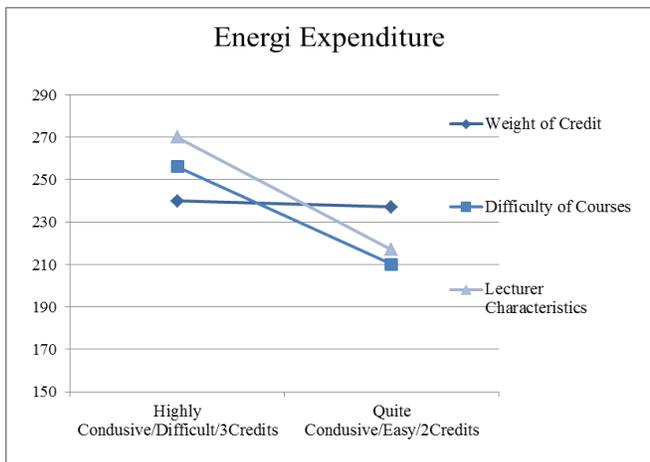
Figure 4. Energy Expenditure Chart

From the figure above, it can be seen that the weight of credit graph is very thin decline towards 2 credits, however tends to look flat. Because the change is too small so that the calculation with Anova method showed there no significant influence of weight of credits change to energy expenditure factor. That caused by the duration length of the lecture activity did not significantly affect a person's energy expenditure, but the better quality of thinking in lecture activities, require more energy expenditure. So the duration length of the lecture does not require more energy expenditure when not offset by the better quality of student thinking.
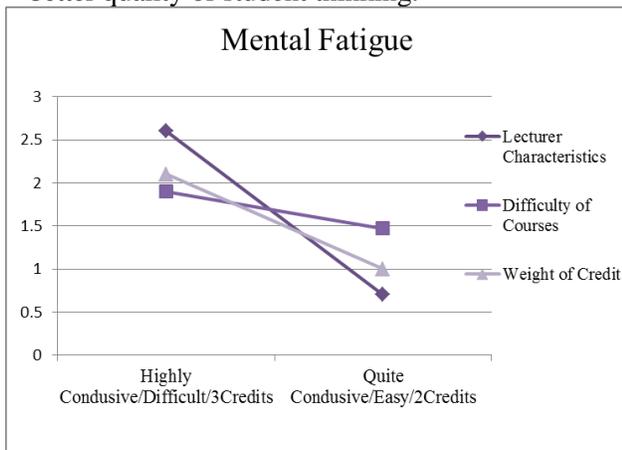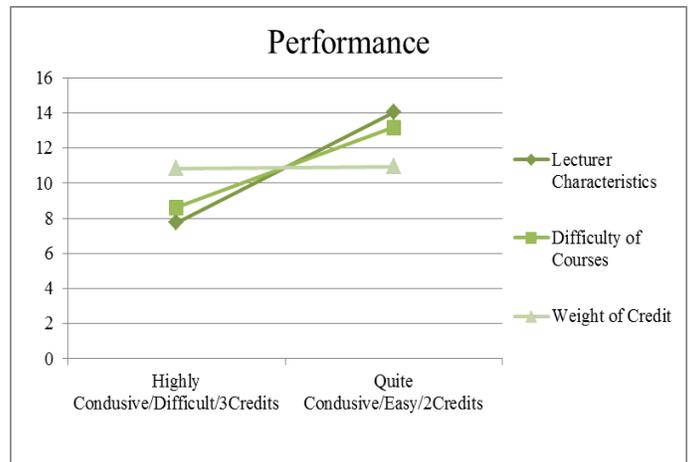

Figure 5. Mental Fatigue Chart

Figure 6. Performance Chart

From figure above, it can be seen that the weight of credits graph are nearly equal between points 2 credits and 3 credits. So that the calculation from ANOVA method showed that there was no significant effect of changes in the weight of credits for the level of performance. It can be happen because the duration of a mental activity does not affect performance degradation. Because in actually lectures activity, if the lecture activity lasts longer but student does not required to think and concentrate, then the mental activity will not getting hard so that only an increase in quantity, not quality of mental activity, so there is nothing significant reduction of the performance level in class with 2 credits and 3 credits.

Recommendations for arrange a courses schedule is also done to increase the performance of students in order to prevent the excessive of energy expenditure and mental fatigue, and a reduction of student performance. According to Christensen (1991), Arham (2015) and BSN (Badan Standardisasi Nasional), the table below is the classification of energy expenditure based on the workload.

Table 5. Workload Assessment

Workload	Calorie Requirement (Cal/hour)	Heartbeat (beat/mnt)	O2 Consumption (l/mnt)
Light	100-200	75-125	0,5-1,5
Medium	>200-350	125-175	1,5-2,5
Heavy	>350-500	>175	2,5-4

Good mental activity based on energy expenditure is on light criteria. While based on the Borg Scale, that consists of 6-20 interval scale that each scale has a mental fatigue significance level (1982), a good level of mental fatigue is in the category Fairly Light which has a value between 10-12 Borg scale. So depend on this assessments and the student performance

data that has been obtained, we can determine the course scheduling recommendations. The following data is the average of energy expenditure, level of mental fatigue, and performance of the students.

Table 6. Recapitulation of Energy Expenditure, Mental Fatigue, and Performance

Lecturer Characteristics	Difficulty of Course	Weight of Credit	Average of		
			Energy Expenditure	Mental Fatigue	Performance
Highly Condusive	Difficult	2	259,198	11,4	14,885
		3	257,0238	11,2	6,8006
	Easy	2	292,682	9,6	1,7624
		3	248	11,2	6,905
Quite Condusive	Difficult	2	278,04	10,4	2,41
		3	258	10,8	2,832
	Easy	2	118,4586	8,8	-1,4802
		3	209,2628	10,4	1,505

Recommendations for courses schedule arrangement that can be done are presented in the following table.

Table 7. Recommendations for Courses Schedule Arrangement

Lecturer highly condusive, Difficult course, 2 credits		Lecturer highly condusive, Easy course, 2 credits		Lecturer quite condusive, Difficult course, 2 credits
Lecturer quite condusive, Easy course, 2 credits	Or	Lecturer quite condusive, Easy course, 3 credits	Or	Lecturer quite condusive, Easy course, 2 credits
Lecturer highly condusive, Difficult course, 3 credits		Lecturer highly condusive, Easy course, 3 credits		Lecturer quite condusive, Difficult course, 3 credits
Lecturer quite condusive, Easy course, 3 credits		Lecturer quite condusive, Easy course, 2 credits		Lecturer quite condusive, Easy course, 3 credits

From Table 5 it can be seen that the good energy expenditure is 150 Calories per hour, so for 100 minutes duration classes should generate 250 calories for good energy expenditure. For the first combination specified very conducive lecturer, difficult course, weighs 2 credits, can be seen through table 6 generates energy expenditure amounted to 259,19 calories, mental fatigue level of 11,4, and the performance level of 14,88. It can be seen that class has exceeded the good energy expenditure and good mental fatigue limit, as well as a high score at the level

of performance that indicates the level of performance is getting lower because it has a scale smaller the better value, so next courses must be balanced with the class that generate the low score of energy expenditure and mental fatigue and high score of performance in order to avoid the excessive imposition of energy expenditure and mental fatigue in a day continuously. Therefore, the next class is recommended that classes with quite conducive lecturer, easy courses, weighs 3 credits that generate 118.45Cal energy expenditure, 8.8 mental fatigue level and -1.42 levels of performance. So as the combination of the next class is determined by that calculation.

5. CONCLUTION

Based on experimental data processing and analysis of energy expenditure, level of mental fatigue, and performance measurement research and answering the purpose of this research, it can be concluded that:

1. Response variable energy expenditure in calories is influenced by the difficulty of courses, lecturer characteristics, and the interaction between the difficulty of courses and lecturer characteristics.
2. Response variable mental fatigue level in Borgscale is influenced by the characteristics of the lecturer factor, weight of credit factors, and the interaction between difficulty of the course and weight of credits.
3. Response variable performance level in time scale is influenced by the characteristics of the lecturer factor, the difficulty of the course factor, and the interaction between difficulty of the course and weight of credits.
4. The most optimal of student's energy expenditure, mental fatigue, and performance is obtained with a combination of quite conducive lecturer, easy courses, and weighs 2 credits.

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