MODELLING OF THE PAPER PLANE SYSTEMS

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ABSTRACT

The purpose of this research is to examine and demonstrate the throwing of paper planes. The concept and objective of this demonstration is tested in various designs and type of the paper planes. The design of research is created to analyse the effect of parameter and treatment to the distance of flying air plane. There are two kinds of factors which includes controlled and uncontrolled factors. The first factor is controlled factors; genders, weight of plane, width of wing and paper type are the interested factors in this research. However, this research does not consider the uncontrolled factors. The result of this testing will be analysed by using JMP program to find consequence of ANOVA testing. The analysing from ANOVA test is normal population, constant variance, random and independent. One-way ANOVA and full factorial analysis result. The concept of the research which gains data analysis graphs from ANOVA test and explanations for those graphs also include in this research.

Keywords—Paper Plane, JMP program, ANOVA

Introduction

Design of research offers a practical approach for exploring multi factor opportunity spaces that exist in almost all real-world situations. Using multi factor experiments which can tease out the effect of an individual factor and hence learn more quickly at minimum cost. JMP offers leading-edge capabilities for optimal design of experiments. JMP also offers analysis in a form can easily use and includes a rich set of modelling methods (JPM 2011). This research will monitor the using of JMP software to analyse the various data which is collected from the experiment. The demonstration display the throwing paper planes in different kind of papers by considerate to many factors such as weight of paper plane, gender of thrower, type of paper and environment. Moreover, this research will present the concept and object of the experiment which gain data analysis graphs from ANOVA test and some explanations for those graphs.

Objective

There are variable of the design for paper planes in order to apply in difference purpose. For this reserch, the length or distance of flight has been identified as the response variables which are considered in four factors that can affect the length or distance of the flight. The factor includes type of paper, weight of the plane, width of the wing and gender of experimenter. However, the purpose of this research is to study the difference in mean of each factor which is affected to the flight distance and discover the best value of each factor which gives the maximum value of flight distance. The three basic concept of experiment design are randomisation, replication and blocking (Montgomery, 2005).

2.1 Randomisation

The statistical process study usually requires the observations be independently distribution random variables. Therefore, it is essential to apply the random table within the experiment to ensure the experiment that can be done by random process. The random order can be generated by random table (Ye, Liu, Ren, Okafo, 2000)

2.2 Replication

The estimate of experiment error can be obtained by replication. Therefore, the number of repeat study should be considered. According to the rule of thumb, a minimum of 6 repeat tests should be including to estimate the error of standard deviation (Mason, Lee, Richard, Hess and James, 2003).

2.3 Blocking

Blocking is a design technique use to improve the precision of experiment by reducing the effect of the nuisance factor which is not interested in this experiment. For this experiment, there is no homogenous factor which is effect to the experiment. As a result, it does not consider the effect of block to the model (Qazi, Samuel, Venkatachalam, Uckun, 2003).

Data Analysis

The response is the distance or length of the flight. In addition, gender, paper type, weight of plane and width of the wing is the interested factors in this research. Therefore, it can generate the combination table as follow

Table 1
Factor of Level

Factor	Level 1	Level 2
Paper Type	Thin (80 grams)	Thick (160 grams)
Weight of plane	Low	High
Width of wings	Short	Wide
Gender	Male	Female

From the table 1 it can generate combination table as follow. There are 16 combinations runs require for 1 replicate. Therefore, there are 6 replicates for the experiment which is required 96 runs.

Table 2
Combination Run

Combination Run	Gender	Paper Type	Weight of plane	Width of wings
1	Male	80 grams	Low	Short
2	Male	80 grams	Low	Wide
3	Male	80 grams	High	Short
4	Male	80 grams	High	Wide
5	Male	160 grams	Low	Short
6	Male	160 grams	Low	Wide
7	Male	160 grams	High	Short
8	Male	160 grams	High	Wide
9	Female	80 grams	Low	Short
10	Female	80 grams	Low	Wide
11	Female	80 grams	High	Short
12	Female	80 grams	High	Wide
13	Female	160 grams	Low	Short
14	Female	160 grams	Low	Wide
15	Female	160 grams	High	Short
16	Female	160 grams	High	Wide

Table 3
Average result of distance (m)

		Male				Female			
	Weight	Low		High		Low		High	
Paper Type	Width of Wing	Short	Wide	Short	Wide	Short	Wide	Short	Wide
Thin (80 grams)		8.83	9.55	6.88	7.50	6.48	8.09	5.45	7.00
Thick (160 grams)		13.10	13.76	9.50	10.19	8.39	9.42	6.27	7.30

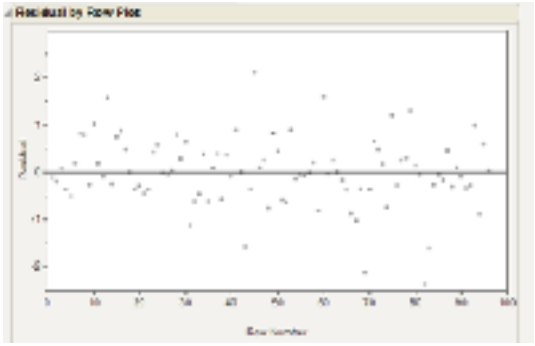
The table 3 displays average result of distance which response from paper type, width of wing, gender and weight of the plane.

Methods

4.1 ANOVA model adequate checked

The research method conduct by random test run and the data for all run is independent. The plotting of residual in time order is help to detect correlation between the residuals. Graph below is a plot of residual versus run order. There is no reason to suspect any violation of independence assumption (JMP, 2011).

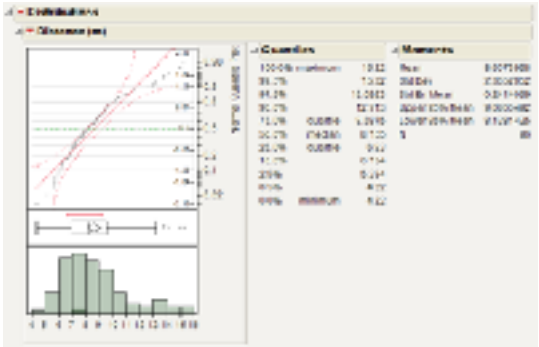
Figure 1
Residual by Row Plot



4.2 Normal Population

Normal quantile plots show the value of the data as a point in a graph. The red straight line and dash line show the boundary of normal distribution. The all value from experiment falls in the normal area. As a result, data is normal distribution (Anderson, Sweeney, Williams, 2006).

Figure 2
Distributions



5.3 Constant variance

According to “rule of thumb”, the ratio of maximum standard deviation and minimum standard deviation is less than 3. As a result, it can be assume that the variance is constant (Lubrano, Ndoye, 2016).

5.4 One-Way ANOVA Analysis Result

One-Way or Single Factor analysis of variance is the investigation process for only one factor. For this research, it was interested in the study of mean difference in each level. Therefore, the each factor ANOVA analysis is conducted by setting alpha value = 0.05

5.4.1 Factor 1: Gender

Ho: $\mu 1 = \mu 2$

H1: $\mu 1 \neq \mu 2$

Where $\mu 1$ is the mean value of flight distance by male

$\mu 2$ is the mean value of flight distance by female

Therefore, fit Y by X model show that the grand mean is equal to 8.607 with R square 0.308. P-Value is less than 0.05. Therefore, the result of mean of distance between 2 levels is significant difference at 95% confident interval.

5.4.2 Factor 2: Paper Type

Ho: $\mu 1 = \mu 2$

H1: $\mu 1 \neq \mu 2$

Where $\mu 1$is the mean value of flight distance of paper type 1 (80 grams)

$\mu 2$ is the mean value of flight distance of paper type 2 (160 grams)

Therefore; fit Y by X model show that the grand mean is equal to 8.607 with R square 0.232 P-Value is less than 0.05. Therefore, the result of mean of distance between 2 levels is significant difference at 95% confident interval.

5.4.3 Factor 3: Plane weight

Ho: $\mu 1 = \mu 2$

H1: $\mu 1 \neq \mu 2$

Where $\mu 1$ is the mean value of flight distance of Low weight

$\mu 2$ is the mean value of flight distance of High weight

Therefore; fit Y by X model show that the grand mean is equal to 8.607 with R square 0.217 P-Value is less than 0.05. Therefore, the result of mean of distance between 2 levels is significant difference at 95% confident interval.

5.4.4 Factor 4: width of wing

Ho: $\mu 1 = \mu 2$

H1: $\mu 1 \neq \mu 2$

Where $\mu 1$ is the mean value of flight distance of short wing

$\mu 2$ is the mean value of flight distance of wide wing

The result from Fit Y by X model show that the grand mean is equal to 8.607 with R square 0.044 P-Value is less than 0.05. Therefore, the result of mean of distance between 2 levels is significant difference at 95% confident interval.

5.4.5 Full Factorial Analysis result

Conducting the test by apply “Fit Model” test with 95% confident interval or alpha = 0.05. The summary fit result is R square = 0.908527 and R square adjust = 0.891376. The result show the model is good fit and mean of response = 8.67395 m.

5.4.6 Analysis of variance result show the p-value is less than 0.05

Refer to JMP result, there are 8 factors which is affect to the model show as below list

- Gender
- Paper Type
- Weight
- Width of wing
- Gender*Paper Type
- Gender*weight of plane
- Gender*width of wing
- Paper type*weight of plane

Conclusion

There is significant difference in mean of flight distance that review by all factors. There are 8 parameters that affect to the flight distance. This include gender, paper type, Weight, Width of wing, Gender versus Paper Type, Gender versus weight of plane, Gender versus width of wing and Paper type versus weight of plane. The best value meter that influence to longest flight distance of paper plane are factor of gender set at “male”, factor

of paper type set at “Thick (160 grams)”, factor of weight of plane set “Low weight” and factor width of wings set at “Wide wing”.

Future Work

There are some problems about the quality and reliability of paper air plane took place. The paper planes that create to make fly will wear out because the plane drops to the ground several times. This can lead to the error. Therefore, the method to improve the reliability of the paper air plane should be implemented. First of all, adding one or two layers of tape along the nose of the airplane. This method is useful if the nose of the plane flies straight up when thrown, or if the plane nosedives. Secondly, fold the back of the wings upward to provide lift and slow the speed of your plane, and downward to make the plane dive and increase the speed. Finally, if paper plane spiral during the experiments, increasing bend size and wings upward can balance the paper plane and make the paper plane fly straight again. In addition, the descent angle of each experimenter can lead to the error of the experiment result. To reduce this error, work instruction and training should be introduced and verified prior start the experiments.

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