Developing Module of Statistics: Preliminary Research for the Second Year of Aerospace Engineering University Students

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Abstract. Statistics for undergraduate students deal with a variety of issues depending on their major. Although basic statistics should still be mastered, the student need to learn more about their majoring field. While only a few modules or even books were created specifically to meet this demand. As a result, this study assessed the recent textbook used in statistics courses to develop a module. The first phase of Research and Development methods used to gain problems and collect data for the developed module. The current finding revealed that students were less satisfied with the textbook's ability to be learned independently. The textbook's material and examples still far from aerospace problems make students confused about how to relate to their real problems. Also, the major statistical concepts for Aerospace Engineering are still not covered in the textbook. Therefore, the content of the developed module is organized by this study to meet the requirement concept material to be mastered by Aerospace Engineers.

Keywords: Development · Module · Statistics · Aerospace Engineering Students

1 Introduction

Statistics are important in engineering processes [1] for example in aerospace engineering Weibull distribution use for rating the failure of aircraft component, Binomial distribution use for evaluating the service quality of airport system and these materials should be mastered by the Aerospace Engineering University Students in their second year. Meanwhile, teaching statistics course for university students can be extremely challenging [2]. Since statistics for university students have special request for each major to fits with the needs of the major in the future.

There are some statistics books are made for special purposes like a book of Charles Ebeling with title an Introduction to Reliability and Maintainability Engineering by McGraw-Hill in1996 [3] which provide many materials that used for engineers, but a few of them specifically made for aerospace engineers. A book titled Experimental Statistics and Data Analysis for Mechanical and Aerospace Engineers written by James A. Middleton in CRC Press Taylor & Francis Group in 2022 is the closest one of the

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criteria that provide statistics material particularly of aerospace engineers [4]. However, these books have too much information for students who will learn about statistics for aerospace engineering university students in 3 credits course. Thus it is still need to develop a module that can simplify the material accordance with the needs of aerospace engineering university students.

Here this article will do the preliminary research of R&D by evaluating the textbook that has used for teaching Statistics and Probability classroom recently for the second year of aerospace engineering university students to gain the data and problems. Then, the data collected will be used to arrange the material and example which concern on aerospace field in order to develop module of Statistics for the aerospace engineering university students.

1.1 Literature Review

Most of aerospace accidents are caused by the failure of aerospace engines [5]. Aerospace Engineers must learn how to predict and prevent that accidents by estimating the remaining useful life of the engines. Also, there are many assessment performances of reliability and residual life on aerospace engines need distribution formula. For example, calculating the average life of electronic aerospace single-machine product through exponential distribution while the non-electronic use Weibull distribution [6]. As a result, the statistics module that will be taught to Aerospace Engineering Students must have significant engineering and practical for the future aerospace engineering.

2 Methods

2.1 Research Design

This study used Research and Development (R&D) methods. Research and Development (R&D) is research methods that used to make a specific produce and test the effectiveness of the product [7]. It is also defined as a process to develop a new product or refining existing products, which can be accounted for [8]. The products that made from a research and development is aimed to increase educational productivity of the educational professions [9]. Thus, the research and development that used in this study are modified from 10 steps which are 1) gaining the problems, 2) collecting data, 3) designing module, 4) design validation, 5) design revision, 6) testing module, 7) product revision, 8) testing on users, 9) product revision and 10) mass production [10]. By this study, these 10 steps will be classified into three main phase called preliminary research, main research and post research as drawn in the flowchart on Fig. 1.

2.2 Research Context

These classification is based on the needs and context of this study which is need to revise the previous textbook used in the course recently [11]. Thus, the development of the module is still on the preliminary research because it is in accordance with the aims of this study that will examine the effectiveness of the previous textbook used in course

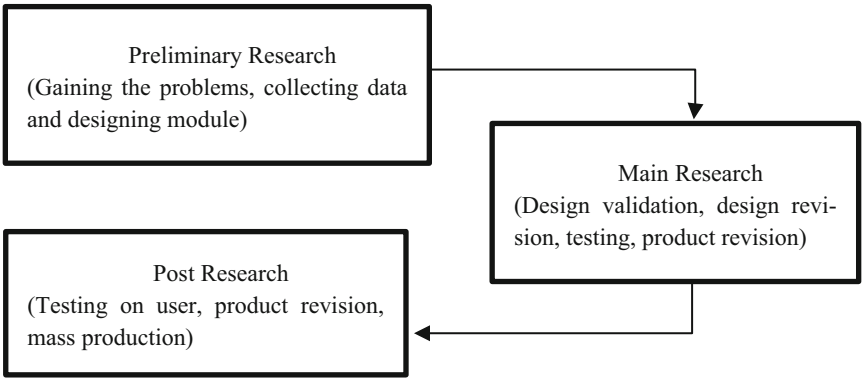

Fig. 1. R&D methods of Borg & Gall phased modifying in this study

of statistics and probabilistic. Based on those analysis, this study will come to design the module that specifically made with the material needs for aerospace engineering university students.

2.3 Population and Data Collection

Mathematics are used generally for almost all major in university. This study will show what is required from statistics by Aerospace Engineering in order to be learned in the second year of University in Indonesia.

Data collecting instrument that used in this study is literature review, questionnaires and interview. Literature review is conducted to gain the problems of aerospace engineering students when learn statistics. Followed by the questionnaire that used to obtain the satisfactory of the textbook in the course as collecting the data of the preliminary research phase in this study. Data collection spanned a semester of the Aerospace Engineering University Students took the Statistics and Probabilistic Course. They are 40 students of Aerospace Engineering in one of Private University in Yogyakarta, Indonesia. The University is concerning to birth an Engineering.

2.4 Data Analysis

The data is further analyzed statistically and used as a reference for developing the module. Interview with the Aerospace Lecturer also become the supporting data to develop the module. Designing the module become the last steps did in this study.

As a mathematics lecturer, I want to make sure that students will understand the material. Since I am teaching mathematics for special purposes, which is for Aerospace Engineering, so I must adjust the mathematics material with the requirements of Aerospace Engineering Field. My students, Aerospace Engineering University Students, need some learning emphasis on several material of statistics like Weibull distribution or Exponential Distribution that they will use in their Thesis and future job. Therefore, we need to rearrange the material of statistics that will taught for this students which will be done by this study.

Based on conception of validity as a unitary concept, this study applied literature review to the concept of construct validity [12]. Since literature review are construct measurements, researchers' interpretations of the meaning of existing literature evaluations [13]. Furthermore, the questionnaire catches the aims to collect relevant information in the most reliable and valid way possible [14] and maximized by the interviews conducted towards the participants.

3 Results and Discussion

3.1 Student's Course Perception

The questionnaire gave to the aerospace engineering students shows that overall they are satisfied with the material and also the textbook of the course as shown in Table 1. But still many students thought that the material is still too difficult to understand.

Furthermore, based on the interview with a lecturer that majoring of Aerospace Engineering toward what kind of statistical material need in their job, we get several compulsory materials to be taught for these student such as; Linear Regression, Multiple Linear Regressions, Hypothesis Testing (proportions, means and frequencies – z-test & t-test), Probability Distribution (Weibull, Normal, Lognormal, Binomial) and Forecasting (Time Series, Exponential, Moving Average). Those material are important to be mastered especially for aerospace engineering students who choose aircraft maintenance as their concentration.

Table 1. The questionnaire about the textbook used in the course of statistics

No	Questions	Percentage	Interpretation Score
1	Did the material of Statistics course too difficult to understand?	68,12%	Agree
2	Did the discussion on the textbook help you comprehend the material?	78,75%	Agree
3	Did you refer the procedure solving problems of the textbook to write your own answer?	79,40%	Agree
4	Did you think that the procedure solving problems of the textbook appropriate to use in write your solution?	74,40%	Agree
5	Do you want any module like the textbook?	72,50%	Agree
6	How far do you understand when you read the textbook?	72,50%	Agree
7	Do you recommend the textbook to others students who learn statistics?	81,25%	Very Agree
8	Did you still need others sources (YouTube video or book or blog or lecturer explanation) when comprehending the textbook?	88,12%	Very Agree

Table 2. Reliability Test Result of Questionnaire Instrument

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.777	.780	8

The 8 questions asked in questionnaire to collect ordinal data, namely P1, P2, P3, P4, P5, P6, P7, and P8 are asked in the form of a Likert Scale 1 to 5 with the questions describe on the Table 1. The questionnaire instrument reliability test was conducted with result on Table 2.

From the result of Cronbach's Alpha Reliability test, the measurement scale 0,777 is bigger than 0,70. Therefore, it can be concluded that measurement scale of the questionnaire about the textbook used in the course of statistics have good reliability.

Meanwhile, from the item-total statistics as the Table 3, showed that P1 and P8 should be revised or deleted due to the score of Cronbach's Alpha if item deleted is higher than Cronbach's Alpha 0,777. P1 has $0.798 > 0.777$ and P8 has $0.792 > 0.777$.

Overall, students like the textbook used for the course, they also recommend it to be learned since it has additional part such a discussion to explain the table or the figure of the example given in the book. This textbook also provides the procedure of the solution in detailed, but it contradicts with the answer of the questionnaire P8 which shows that students still need additional sources to comprehend the textbook. The result of questionnaires showed students like the textbook but in P1 said that the material of statistics is too difficult also being other contradiction. Thus, the questions of P1 and P8 should be revised or deleted also based on Cronbach's Alpha Item Score in Table 3.

The result shows the opposite result, positive in preference but negative for the convenience of the textbook used in the classroom. From some interviews found reason

Table 3. Cronbach's Alpha item of Questionnaire Instrument

Item-Total Statistics					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
P1	27.50	12.410	.214	.193	.798
P2	27.15	11.156	.651	.558	.729
P3	27.15	11.464	.454	.455	.757
P4	27.33	10.379	.656	.561	.721
P5	27.25	9.731	.689	.568	.711
P6	27.45	11.895	.362	.272	.772
P7	26.95	10.715	.665	.585	.723
P8	26.58	12.661	.222	.063	.792

of the dissatisfaction of students on the textbook in the statistics course. They said that the example solution provided in the book is too long as Fig. 3. As the typical of engineering students who like to the point [15], the long explanation will not be liked, simpler one is chosen as in Fig. 4.

The context of the textbook example which do not related with aerospace context also become discontent of the students. In the example of Fig. 2, it used the data of age and blood pressure rather than the data of passengers in the airport within certain years. For engineering students, the context of airport passenger more familiar and comfortable. It will also easily remind them the use of linear regression toward their jobs when they talked about it later on.

It is known that engineering' students are rather people of action rather than of words, so writing is not their favorite activity [15]. Meanwhile, writing is one of way of communication, especially in mathematics writing your solution is like communication with the readers. Therefore, the way to write mathematical solution problem on the textbook of statistical and probability course also highlighted in the students' questionnaires. Their responses that 74% of them has agree with the way it write the solution. The rest of students who did not agree like the simpler way of text explanation of solution. They might know that the long explanation is useful for them to understand but they prefer not to adopt it as their solution writing. Their communication media using equation

Seberapa bagus model ini? Dapat dilihat pada Model Summary.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.947[a]	.896	.870	3.65209

a. *Predictors*: (Constant), usia
b. *Dependent* Variable: tekanan darah

Fig. 2. The SPSS result of model summary in linear regression

Model *summary* menampilkan koefisien korelasi Pearson, r = 0,947 dan koefisien determinasi, R^2 =0,896. Sesuai dengan perhitungan sebelumnya (dengan pembulatan). Interpretasi hasil sama seperti sebelumnya, yaitu sekitar 89,6% variasi nilai-nilai y dapat dijelaskan oleh x berdasarkan regresi linier sederhana. Sedangkan sisanya sebesar 10,4% variasi nilai-nilai y dapat dijelaskan oleh faktor lain.

Fig. 3. Long Explanation

Output Model Summary

Seberapa bagus bubungan antar variabel dapat diketahui melalui output Model Summary. Berdasarkan output Model Summary, diperoleh informasisebagai berikut:

a) Nilai r = 0,947, berarti tingkat hubungannya tinggi
b) Nilai koefisien determinasi r^2 = 0,896, berarti 89,6% variasi nilai – nilai y dapat dijelaskan oleh x sedangkan sisanya 10,4% dijelaskan oleh faktor lain.

Fig. 4. Simpler explanation

and symbols describe the implication of their calculations and being addressed to an intelligent as technical audience. Therefore, they prefer the simpler answer solution.

The lack of statistics books or module that focused for Aerospace Engineers decrease the Aerospace Engineering Students to learn widely. Actually, NASA published a book titled Probability and Statistics in Aerospace Engineering from 1998 but it is too brief and less of explanation. While all of the Indonesian books version are for general Statistics such as Statistika: Teori dan Aplikasi Jilid 1 dan 2 by Supranto [16] and also Statistika Tanpa Stres by Abdullah and Edy Sutanto [17].

Furthermore, not all of material in that books can be mastered by the students due to the priority of material use for job and lack of time. Mostly lecturer will not connect the example of the material into aerospace engineer cases. Whereas, most students will use the material when they do their thesis. So, most of students have difficulties to relate it with their thesis. They need more time to relearn the material of statistics for aerospace engineering. This make students cannot comprehend the material deeply since they are worried and not confident toward the material of statistics [1].

Therefore, it is need to develop a module of statistics which focusing on material that related directly into aerospace engineering or at least using the context of aerospace engineer.

3.2 Designing the Module

In order to design an educational module of statistics for aerospace engineering, we have to answer two main questions, what knowledge and competences are needed? How to present the material according to the engineering students character? The module will contain concepts in probability, statistics, random process and estimation theory from an engineering point of view and their use in aerospace engineering [18]. The reference book of "Probability and Statistics in Aerospace Engineering" by M.H Rheinfurth and L.W. Howell by NASA in 1998 [19] suggested some material that needs to be taught. Combined with the book of "Experimental Statistics and Data Analysis for Mechanical and Aerospace Engineers" written by James A. Middleton [4] and "The standard book for Aeronautical and Astronautical Engineers" by Mark Davies in Mc-Graw Hill in 2004 [20] and also from the textbook Statistika tanpa stress [17] which has been analyzed statistically, this study decided to rearrange the material of learning statistics and probability for aerospace engineering on the module. The learning objectives of each material in the module are students will be able to the following objectives of material:

1. Introduction
   a. Defining statistics
   b. Categorizing the types of data
   c. Associating the technique of sampling
   d. Displaying data in various way like table, histogram, bar chart, pie chart, line chart and pictogram
2. Averages (data centering)
   Calculating Mean, Median and Modus
3. Dispersion (data distribution)
   Calculating Quartile, Desile, Percentile, standard deviation and Variance.

4. Skewness & Kurtosis
   a. Calculating the skewness and kurtosis by SPSS & Excel with aerospace context
   b. Drawing the graph and read the graph of skewness and kurtosis with aerospace context
5. Combinations and Permutations
   a. Calculating permutation and combination
   b. Calculating Bayes Theorem with aerospace context
6. Regression and Correlation
   a. Calculating simple linear regression and double linear regression with manually and using software SPSS with aerospace context
   b. Calculating correlation test with manually and using software SPSS with aerospace context
7. Hypothesis Testing
   a. Calculating validity test instrument, normality test, homogeneity test manually and using software SPSS with aerospace context
   b. Calculating one sample t-test, paired sample t-test, Anova, Pearson product moment manually and using software SPSS with aerospace context
8. Probability Distributions
   a. Identify criteria of each probability distribution
   b. Calculating each probabilities distribution below with aerospace context
      1) Bernoulli Distribution
      2) Binomial Distribution
      3) Normal Distribution
      4) Hypergeometric Distribution
      5) Weibull Distribution
      6) Poison Distribution
9. Path Analysis. Describing the aim and the stages of path analysis with aerospace context

Based on the objectives above, we create a module of statistics and probability that specialized for aerospace engineering students. By designing the module with the learning objectives that suitable with the needs of aerospace engineering students, it is facilitating the lecturer to determine whether the learner has achieved the objective [21]. Students also more interested to learn using module rather since they can engage with the process due to the problems given in the module [22].

4 Conclusion

Statistics for Aerospace Engineering continue to receive little attention in teaching and learning activities. People believe that Statistics in general will be the same. Meanwhile, there are many cases where engineers who are not aerospace engineers have difficulty understanding aero terminology, even simple terms like flying physics and turbo engines. Furthermore, the textbook used in this study is still difficult to understand, despite the fact that the procedure for solving problems is simple to follow. Students of Aerospace Engineering still require assistance from other sources as well as from the lecturer. As a result, we require a special module to provide statistics material tailored specifically to

the Aerospace Engineering being developed by this study. The content of the developed module has been organized based on the students' advanced course requirements. Following that, real-world examples and exercises in the Aerospace field use to demonstrate and exercise the concept in the module.

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