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EVALUATION OF SCIENCE IMPLEMENTATION IN MECHANICAL ENGINEERING DESIGN CURRICULUM CLASS 2A STATE POLYTECHNIC OF JAKARTA PEKALONGAN CITY CAMPUS ACADEMIC YEAR 2023/2024

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Abstract

The influence of science in mechanical engineering design is very significant. Science provides a foundation of in-depth knowledge of the principles of physics, mathematics, and chemistry that are used to design efficient and innovative machines. The method used is a quantitative method with descriptive statistics. This method is an approach to research that focuses on data collection and data analysis based on numbers or quantities. From the method presented, it can be concluded that this method can make it easier to make better decisions based on structured numerical information. The results of this research refer to 3 parameters, namely kurtosis value, maximum value and minimum value. several other parameters are also displayed such as mean value, standard error, median, mode, standard deviation, sample variance, skewness, range, sum and count. It can be concluded from this study that the data does not have a normal distribution because the kurtosis number is not 0. Based on the data descriptive statistics, the maximum value in this study is 31, the minimum value in this study is 20.

Keywords— Normal distribution, maximum value and minimum value.

INTRODUCTION

Advances in materials science have enabled engineers to develop new materials that are stronger, lighter and more durable (Mubina Dewadi et al., n.d.). Composite materials, metal alloys, and nanomaterials are some examples of innovations resulting from scientific research (Kusmiwardhana et al., 2024). These materials not only improve engine performance but also help reduce weight and manufacturing costs (C. Wibowo, Mubina Dewadi, et al., 2024). Physics and mathematics play an important role in the analysis of machine structures (C. Wibowo, Dewadi, et al., 2024). Using numerical methods such as finite element methods, engineers can simulate and analyze stresses, strains, and deformations in machine components (Khoirudin et al., 2021). This allows them to detect potential failures and optimize designs before prototypes are built (Abbas et al., 2021). The purpose of this study is about whether the data is normally distributed or not, what is the minimum value and what is the maximum value (Nurmiah, A., Hasriyanti, et al., 2023).

Energy-efficient mechanical engineering is one of the main focuses in modern design (F.M. Dewadi, Milasari, A, et al., 2023). Science helps in developing more energy-efficient machines through research in thermodynamics and fluid mechanics (Yusaerah et al., 2022). For example, the development of more efficient internal combustion engines, wind turbines, and electric vehicles all rely on scientific knowledge to optimize energy use and reduce emissions (Lulut Alfaris, S.T. et al., 2022).

Science serves as a strong foundation in mechanical engineering design (Ratnadewi et al., 2023). Through research and technological developments, engineers can create more innovative, efficient and environmentally friendly machines (F. Dewadi et al., 2024). The development of new materials, more accurate structural analysis, and improved energy efficiency are some examples of how science influences and drives progress in the field of mechanical engineering (Mustafa et al., 2023).

The influence of science in mechanical engineering design is significant because science provides the theoretical foundation and deep understanding of the principles of physics, mathematics, and materials needed to design and develop effective and efficient machines (Yunus et al., 2023). Science provides the theories underlying the basic principles that apply in machine design, such as Newton's laws for dynamics, energy principles for thermodynamics, and material strength theory for structural analysis (Nugroho et al., 2023).

Scientific knowledge enables engineers to innovate and develop in machine design (Wiyono et al., 2023). By understanding the physical and mathematical phenomena underlying machine components, they can create more efficient, robust and durable solutions (Darmayani et al., 2023). Science enables designers to optimize machine performance by predicting machine behavior under various operational and environmental conditions (Purnomo & Sahabuddin, 2023). This includes mathematical modeling for simulation, strength analysis, and design optimization (Fathan et al., 2023). Knowledge of material properties and material manufacturing processes allows engineers to select the right material for each machine application, taking into account factors such as strength, sustainability and cost (Fathan et al., 2023).

Science is also the basis for the development of advanced technologies in fields such as automation, control and artificial intelligence that increasingly influence the design and operation of modern machines (F. Dewadi, Octavianti, et al., 2023). Science plays a central role in expanding the boundaries of possibility in mechanical engineering design, ensuring machines can operate optimally, efficiently and safely in a wide range of industrial and everyday life applications (F. M. Dewadi, Nova, et al., 2024).

Newton's principles of motion are the basis for understanding the behavior of solid bodies under certain forces and moments (Mudia et al., 2023). It includes equations of motion, momentum, and kinetic energy that are important in machine analysis, such as particle motion, velocity, and acceleration (N et al., 2024). The science of energy and its transformations (F. M. Dewadi, Puspita, et al., 2024).

It includes the laws of thermodynamics underlying engine efficiency, heat transfer, and thermal cycles such as the Carnot cycle or Rankine cycle in heat engines (Sugiyanto et al., n.d.). The science of fluid behavior (gas and liquid) and its application in the design of fluid machinery such as pumps, turbines, and compressors (Simatupang et al., 2013). This includes basic fluid laws such as Bernoulli's law and Navier-Stokes equations (C. Wibowo et al., 2023). An understanding of the mechanical and thermal properties of materials such as elasticity, strength, hardness, and brittleness (F. M. Dewadi, Farahdiansari, et al., 2023). These are important in the structural design of machines and selection of suitable materials (F. M. Dewadi, Sriwahyuni, et al., 2023).

Fundamentals of electricity and electronics relevant for machine control, automation systems, and integration of digital technologies in modern machines (Alfianto et al., 2023). Mathematics is a key tool in machine analysis and design, including calculus for integration and differentiation, linear algebra for vector analysis, and numerical methods for computer simulation (F. M. Dewadi, n.d.-b). A deep understanding of these theoretical foundations enables engineers to design machines that not only function well under ideal conditions but can also overcome practical challenges and operational activities in the field (Dahri et al., 2023). By using science as a foundation, designers can create innovative and efficient solutions in the ever-evolving machine technology (Nanda, Dewadi, et al., 2023).

In-depth knowledge of scientific principles such as mechanics, thermodynamics and fluid mechanics enables engineers to identify technical challenges and create new solutions to improve machine performance (F. M. Dewadi, Kristiana, La Ola, et al., 2023). Advances in technologies such as computing, sensorics and materials enable the development of more sophisticated and efficient machines (F. Dewadi, Kusmiwardhana, et al., 2023). For example, the use of computer modeling and simulation technologies allows designers to virtually test various designs before building physical prototypes (F. M. Dewadi, Milasari, Hermila, et al., 2023).

With the help of mathematical modeling and simulation, engineers can optimize machine designs to meet various performance requirements such as strength, stability, and energy efficiency (F. M. Dewadi, Wibowo, et al., 2023). This includes the use of optimization algorithms to find the best solution in the design of machine components (Santosa et al., 2022). Modern machines often consist of various complex systems, such as control systems, sensor systems, and drive systems (F. M. Dewadi, 2021e).

Innovation in design involves integrating these systems synergistically to achieve optimal performance and efficient use of resources (Nanda, Supriyanto, et al., 2023). Sustainability aspects are gaining importance in machine innovation (F. M. Dewadi, Nanda, et al., 2023). Designers strive to reduce the environmental footprint of machines by using eco-friendly materials, improving energy efficiency, and designing for longer life cycles and easier recycling (Mubina & Amir, 2022). Innovations in machine design are often triggered by market demands for better performance, lower costs, or ease of operation (Nanda, Karyadi, et al., 2023). Engineers must be able to respond quickly to these changes with new and advanced solutions (F. M. Dewadi, 2021d).

Innovation and development in mechanical engineering design is the result of the integration of science, technology and evolving market needs (Kusmiwardhana et al., 2023). This process drives progress in industry and brings significant benefits in improving the efficiency, reliability and sustainability of modern machines (F. M. Dewadi, 2023e).

Kurtosis is a statistical measure that describes how steep or flat a data distribution is compared to a normal distribution (Nanda, Karyadi, & Dewadi, 2022). Although kurtosis is not specific to the field of mechanical engineering, it can have some relevant applications in research in the field (F. M. Dewadi, Jati, et al., 2023). In mechanical engineering, it is often the case that the data generated can have a non-normal distribution (Fathan et al., 2022).

Using kurtosis can help researchers to understand how far their data distribution is from the normal distribution, so as to choose the appropriate statistical method for further analysis (Suhara, Dewadi, & Hamdani, 2023). High levels of kurtosis can indicate the presence of outliers or data that is far from the average, which may need further attention in a mechanical engineering context to evaluate the reliability or consistency of the data (F. M. Dewadi & Supriyanto, 2021).

In the development of models or predictions in mechanical engineering, understanding the kurtosis of the variables involved can help in selecting an appropriate distribution to model the data, such as the normal distribution or other more appropriate distributions (F. M. Dewadi, 2023f). In performance or characteristic comparison research between two or more systems, kurtosis can be an indicator to compare the distribution of data generated by each system (F. M. Dewadi & Sigalingging, 2021).

In the development of an engineering product or component, the maximum and minimum values of various parameters such as material strength, dimensions, or tolerances can be crucial design criteria (F. M. Dewadi, Reynaldi, et al., 2021). Knowing these limits helps the engineer in determining the appropriate specifications for the product to function properly and safely in the desired environment (Nanda & Dewadi, 2022).

In manufacturing processes, the maximum and minimum values of parameters such as temperature, pressure, or speed can determine the quality and consistency of the final product

(Jakariya et al., 2023). Measuring and controlling these values is important to ensure that the production process runs within the desired limits to produce products that meet quality standards (Della et al., 2022).

In research on component or system failure, knowing the maximum and minimum values of the load or operational conditions that the component can bear is key information to understand the cause of failure or to improve reliability and service life (Lulut Alfaris et al., 2022). In the context of system or component performance optimization, understanding the maximum and minimum values of parameters such as efficiency, speed, or energy consumption can help in designing more effective and efficient systems (F. M. Dewadi et al., 2019b). In design and manufacturing, the maximum and minimum limits of dimensional or geometry tolerances are critical to ensure that component parts fit correctly and function as intended (C. Wibowo, Setiawan, et al., 2021).

Data processing in Excel has a very important role in research, including in the context of mechanical engineering (Abbas et al., 2021). Excel allows researchers to organize data in a way that is structured and easy to understand (C. Wibowo, Dewadi, et al., 2021). Data from multiple sources can be imported and organized into neat tables or worksheets, making it easy to run further analysis (Dimyati et al., 2021). Excel offers various functions and formulas to perform data manipulation, such as basic statistical calculations (mean, median, standard deviation), combining data from various sources, or data transformations required before advanced analysis (Ma'arof et al., n.d.). Graphs and diagrams created in Excel help researchers to visually analyze and present data (F. M. Dewadi, 2021b). This not only makes it easier to understand patterns and trends in the data, but also makes it easier to communicate research results to other parties (C. Wibowo & Dewadi, 2022). Although Excel is not on par with specialized statistical software such as SPSS or R, it has basic capabilities for performing statistical analyzes such as t-tests, ANOVA, linear regression, and others (F. M. Dewadi, 2023b). This is sufficient for initial analysis before moving on to more advanced statistical tools if necessary (Nanda, Karyadi, Dewadi, et al., 2022).

Excel makes it possible to share and edit data collaboratively among research team members (Murtalim et al., 2020). Additionally, Excel worksheets can serve as reference documents that can be saved and accessed again for re-analysis or study replication (Farahdiansari et al., 2021). The normal distribution makes it possible to use stronger and more reliable parametric statistical methods, such as hypothesis testing and confidence intervals (Mulyadi & Dewadi, 2021). This is important because many statistical analysis techniques are based on the assumption that the data is normally distributed (Khoirudin et al., 2021). Data that approximates a normal distribution tends to be more consistent in behavior and easier to predict (Suhara, Dewadi, & Febrian, 2023). This simplifies the interpretation of research results and describes the behavior or performance of the system under different conditions (Nanda, Supriyono, Ma'arof, & Dewadi, 2022). Results from research that uses normally distributed data tend to be more easily generalized to a wider population (F. M. Dewadi, 2021a). This is important in the context of mechanical engineering applications where consistency and consistency of data is highly required (Mubina Dewadi et al., n.d.). Understanding the maximum and minimum values of the parameters involved in the research makes it possible to design products or systems that are more reliable and comply with established quality standards (Dewadi. Fathan et al., 2024). Maximum and minimum value limits are critical in ensuring the safety and performance of an engineering system or component (Nurmiah, A., Nunik Hasriyanti, et al., 2023). This helps in identifying potential failures or risks associated with operating outside its limits (Minuk Riyana, S.Pd. et al., 2022). It is important to remember that while a normal distribution is a common assumption in many statistical analyses, not all data in a mechanical engineering or other scientific context will be exactly normally distributed (Muryanto et al., 2023).

RESEARCH METHOD

Questionnaires help researchers collect data in a structured and systematic way (F. M. Dewadi, Kiswanto, et al., 2022). It allows researchers to collect consistent information from each respondent, thus facilitating data analysis (Muhammad et al., n.d.). By using questionnaires, researchers can guarantee that all respondents are asked the same questions (F. M. Dewadi, 2021c). This is important to ensure that the data obtained can be compared and interpreted appropriately (F. M. Dewadi, Bachtiar, Alyah, et al., 2023). Questionnaires allow researchers to collect data from a large number of respondents efficiently (Lawi et al., 2023).

This is particularly useful in large population studies where direct data collection or individual interviews may not be practical (F. M. Dewadi, 2023d). Data from questionnaires can often be statistically analyzed to find patterns or relationships between the variables under study (F. M. Dewadi, 2022). This helps in validating hypotheses or answering research questions in greater depth (F. M. Dewadi, 2023c). Questionnaires can be designed to minimize respondent bias or other research biases (F. M. Dewadi, 2023a). In other words, questions can be formulated in such a way that they do not encourage certain answers or do not influence respondents' perceptions (F. M. Dewadi, n.d.-a). Questionnaires can be widely distributed and completed by respondents at a more flexible time (Supriyati et al., 2022). This provides advantages in terms of time and cost compared to more intensive data collection methods such as in-person interviews (F. M. Dewadi, Ma'arof, et al., 2021).

The method used is a quantitative method with descriptive statistics, this method is an approach in research that focuses on data collection and data analysis based on numbers or quantities (C. Wibowo, Sukarno, et al., 2022). From the method presented, it can be concluded that the method can facilitate making better decisions based on structured numerical information (F. M. Dewadi et al., 2019a).

Based on the class or level of complexity, research can be focused on ways to improve efficiency and productivity in manufacturing processes (Asari et al., 2023). For example, research at a high level of complexity might consider the application of automation or robotic technologies to increase output (F. M. Dewadi, Amir, et al., 2022).

Different grade levels in manufacturing research can influence product innovation (F. M. Dewadi & Ma'arof, 2022). Research at a high grade may include the development of new materials, more complex product designs, or the integration of advanced technologies in products (F. M. Dewadi, Lillahulhaq, et al., 2023). This helps manufacturers to stay competitive with innovative products in the market (Nanda & Dewadi, 2023).

Research by class can help understand the factors that affect product reliability and quality (S. H. Wibowo et al., 2023). By understanding specific levels of complexity, manufacturers can design and test their products to ensure reliable performance and high quality (C. Wibowo, Surbakti, et al., 2022).

Research in manufacturing can also focus on reducing production costs (F. M. Dewadi, Maryadi, et al., 2022). Studies on different levels of complexity can help identify areas where manufacturing costs can be minimized without compromising product quality or performance (Mulyadi et al., 2023). Grade level in manufacturing research can also influence the understanding of market and customer needs and preferences (Setiawan & Dewadi, 2022).

For example, research at lower grade levels may be more focused on understanding simple market demands, while research at higher grades may include analysis to understand more complex consumer trends and expectations (F. M. Dewadi, 2016). By considering the grade level or complexity in manufacturing research, researchers and industry can focus on certain aspects that are relevant to their goals, be it in new product development, production process improvement, or more effective financial strategies (Nanda, Supriyanto, Dewadi, Jati, et al., 2022).

CONCLUSION

In conducting this statistical research, several questions are needed where some of these things become statements, namely mechanical engineering design requires science, the number of methods in mechanical engineering design, types of engineering materials, properties of engineering materials, steel including ferrous metals, plastic including nonferrous metals, aluminum including nonmetallic materials, the form of origin of the workpiece is called material, metals that do not contain iron elements are ferrous and rubber at minus temperature is soft. The statement in this study consists of 5 points with number 1 indicating strongly agree, number 2 indicating moderately agree, number 3 indicating agree, number 4 indicating disagree and number 5 indicating strongly disagree. The following will be explained in table 1 regarding the questionnaire analysis in this study.

Table 1. Questionnaire Analysis in This Study (Source: Personal Documentation)

Question	P1	P2	P3	P4	P5	P6	P7	P8	P9	
Q1	2	1	3	3	3	3	3	1	2	
Q2	3	2	4	2	4	1	2	4	3	
Q3	2	4	4	2	4	2	3	5	4	
Q4	2	4	4	2	5	3	4	4	3	
Q5	3	2	2	3	4	2	2	3	3	
Q6	1	2	2	3	5	1	3	1	4	
Q7	4	2	3	4	5	3	3	3	3	
Q8	3	2	2	3	2	1	3	3	3	
Q9	2	2	2	3	1	1	3	3	3	
Q10	5	1	2	3	3	5	3	2	3	
ANSWER										
ΣQ	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
POINT	21	25	30	31	23	22	30	22	20	27

The results of the research that has been done based on descriptive statistics of the influence of science in mechanical engineering design in table 2.

Table 2. Descriptive Statistics Results (Source: Personal Documentation)

No	Parameter	Value
1	Standard Error	1,30343413
2	Median	24
3	Mode	30
4	Standard Deviation	4,121758
5	Sample Variance	16,98889
6	Kurtosis	-1,66163
7	Skewness	0,351308
8	Range	11
9	Minimum	20
10	Maximum	31
11	Sum	251
12	Count	10

SUGGESTIONS

It can be concluded from this study that the data is not normally distributed because the number of kurtosis is not 0. Based on descriptive statistical data, the maximum value in this study is 31, the minimum value in this study is 20.

CONCLUSION

Keep up to date with the latest technologies in modeling, simulation, sensorics, and materials. The application of these technologies can help improve machine quality and performance and reduce development time. Use optimization tools to improve machine design. Proper material selection, efficient geometry, and optimized component arrangement can result in a stronger and more efficient machine.

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