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Importance of the conceptualization of curve fitting in the determination of the elastic constant of a spring

Importancia de la conceptualización del ajuste de curvas en la determinación de la constante de elasticidad de un resorte

Galo Fernando Moya Castillo[1]
Tannia Gabriela Acosta Chávez[2]
Cleitton Alfredo Yance Tutiven[3]
Axel Jefferson Córdova López[4]

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Correspondence author
gmoya@uagraria.edu.ec

Abstract: The purpose of this study focuses on demonstrating a relationship between curve fitting and the calculation of the constant of a spring. To achieve this objective, an evaluation was carried out involving 57 students enrolled in the fifth semester of the Pedagogy in Mathematics and Physics course at the University of Guayaquil; this evaluation consisted of a questionnaire divided into two equal parts, 50% of which included questions about curve fitting, while the other part focused on the calculation of the spring constant of elasticity of a spring. To quantify their relationship, Pearson's correlation coefficient was used, the results of this analysis reflected a coefficient of 0.454, indicating a moderate relationship between the study variables. Thus, the improvement of this knowledge not only contributes to the quality of teaching, but also has a positive impact on the learning process in the fields of physics and statistics.

Keywords: curve fitting, elasticity, spring

Resumen: El propósito de este estudio se enfoca en demostrar una relación entre el ajuste de curvas y el cálculo de la constante de un resorte. Para alcanzar este objetivo, se llevó a cabo una evaluación que involucró a 57 estudiantes matriculados en el quinto semestre de la carrera de Pedagogía en Matemática y Física en la Universidad de Guayaquil; esta evaluación consistió en un cuestionario dividido en dos partes equitativas, un 50% abarcó preguntas acerca del ajuste de curvas; mientras que la otra se centró en el cálculo de la constante de elasticidad de un resorte. Para cuantificar su relación, se empleó el coeficiente de correlación de Pearson, los resultados de este análisis reflejaron un coeficiente de 0.454, indicando una relación moderada entre las variables de estudio. Entonces, la mejora de estos conocimientos no solo contribuye a la calidad de la enseñanza, sino que también incide positivamente en el proceso de aprendizaje en los campos de la física y estadística.

Palabras clave: Ajuste de curvas, elasticidad, resorte

Ph,D. Agrarian University of Ecuador, gmoya@uagraria.edu.ec, https://orcid.org/0009-0006-8872-3570

Ph,D. Agrarian University of Ecuador: tacosta@uagraria.edu.ec https://orcid.org/0000-0002-4740-2213

Ph,D. University of Guayaquil cleitton.yancet@ug.edu.ec, https://orcid.org/0000-0001-8554-7838

Ph,D. University of Guayaquil axel.cordoval@ug.edu.ec, https://orcid.org/0009-0009-2722-8244

Introduction

In the educational environment, physics and engineering education face ongoing challenges related to the understanding and application of complex concepts; one of the critical aspects is the proper understanding of curve fitting in the context of determining the spring rate constant of a spring.

Students and teachers often encounter difficulties in selecting appropriate fitting models, interpreting the results obtained and understanding the relationship between the fitted parameters and the physical properties of the spring. These educational actors play a key role in the transmission and acquisition of scientific knowledge and the lack of solid understanding in the conceptualization of curve fitting can negatively affect the quality of education and training in these areas, impacting the learning of future physics and engineering professionals.

Schemas and conceptualization are key elements for the understanding of human learning. In this sense, a concept cannot be reduced to a simple definition, but must also be associated with specific situations and problems. In addition, Vergnaud stresses the importance of rational knowledge and how it always involves some form of operation or action. These two ideas together, according to Vergnaud, form the basis of effective and meaningful learning (Mendoza, 2020).

On the other hand, the impossibility of having the indispensable elements, the difficulties in accessing adequate equipment and materials to carry out the tests and measurements necessary for the development of experimental practices, makes the creation of a virtual laboratory viable and necessary, which organizes the different simulations, video tutorials and specialized pages; in order to provide the school and the different actors, an environment that complements or even in some cases replaces the existing laboratory (Diaz B. , 2021).

In the field of physics and engineering, the accurate determination of the spring rate of a spring is fundamental to understanding and predicting the behavior of various mechanical systems. Curve fitting, an essential technique in the analysis of experimental data, plays a crucial role in this process by modeling the relationships between the variables involved. The correct conceptualization and application of this technique are vital to obtain reliable and consistent results in the measurement of the elasticity constant. This study explores the importance of the conceptualization of curve fitting in the determination of the elasticity constant of a spring, addressing both the problems in the institution and the contribution of this research in the field of science education.

Methodology

The present investigation contains a non-experimental design, which consists of gathering information from observational data on how the significant understanding of statistics is related to the calculation of the coefficient of elasticity present in Hooke's law; for this purpose, the test is taken as an investigative technique, which will consist of a questionnaire of 20 questions, which will help to check the level of understanding and aptitude related to the conceptualization of curve fitting and the determination of the constant of elasticity of a spring.

The objective of this study is not to evaluate a didactic proposal to improve the learning of statistics or physics, but to measure both variables in a specific content and verify if they are related, and thus propose an adequate pedagogical alternative to the results obtained. That is to say, to carry out a correlational investigation to indicate if there is a relationship, link or connection between the variables such as: the conceptualization of curve fitting with the calculation of the elasticity of a spring.

For this purpose, a thorough review of books, files and documents was carried out to obtain formal and supported data that were appropriate for the research and that ensured the quality and a solid base of the contents evaluated in the test, which will be applied to 57 fifth semester students of the University of Guayaquil belonging to the career of Pedagogy of experimental sciences of Mathematics and Physics, in the real environment of the students, taking advantage of their learning environment.

In this sense, a quantitative modality is followed, due to the obtaining of numerical values and grades obtained in the test; as well as the implementation of descriptive statistics, with which it will be possible to organize, summarize and visualize the data collected, by means of tables and graphs that will differentiate the successes and errors obtained by the students in each of the questions.

Results

The test was based on the analysis of the level of understanding of the elasticity constant and curve fitting, the results obtained are detailed below. Table 1.

Table 1. *Test Results - Elasticity constant and Curve Fitting*

QUESTIONS	ELASTICITY CONSTANT		QUESTIONS	CURVE FITTING	
	ACIERTOS	ERRORS		ACIERTOS	ERRORS
1	21	36	**11**	20	37
2	49	8	**12**	21	36
3	41	16	**13**	30	27
4	32	25	**14**	24	33
5	29	28	**15**	15	42
6	31	26	**16**	30	27
7	27	30	**17**	21	36
8	16	41	**18**	42	15
9	35	22	**19**	32	25
10	39	18	**20**	30	27

Source: Test Results
Prepared by: Daisy Criollo

37% of the students know the correct formula to calculate the constant of a spring, 86% know its unit of measurement, 72% calculate the force applied to the spring from the constant of elasticity and its deformation, as well as 56% of them indicate that if the spring is replaced by a stiffer one the constant will increase, but only 51% infer that it is because they are directly proportional. On the other hand, 54% carry out the corresponding process to know the deformation that the spring has had and 47% specify that if a spring is cut in half its constant will be divided in two. However, only 28% manage to answer correctly what the value of the constant will be based on the frequency and mass that supports the elastic body; while 61% of the trainees indicate that if the spring is stretched beyond its elastic limit it will break and finally, it is 68% who can find the value of the restoring force. It can be visualized that 35% of the trainees can calculate the estimation of the constant of a spring based on curve fitting, 37% indicate that in statistics this is a method to

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approximate a curve from observed data, 53% indicate that it serves to find the equation of a curve that fits the data and 42% mention that it is complemented with the linear regression technique. On the other hand, 26% of the students know how to differentiate the most appropriate type of curve fitting to represent data, 53% can indicate the equation that is closest to the data. Also, when distinguishing the type of curve fitting from graphs, the following results were obtained: 37% recognize the linear fit, 74% resemble the quadratic function and 60% the exponential function.

Calculation of the correlation level

According to the results obtained and with the correct tabulation for the analysis, a certified statistical tool was used to determine the validity of the research instrument, which provided an acceptable value, thus assuring the internal consistency of the application of the test.

Since the research is correlational, we sought to find links or relationships between one variable and another, such as the conceptualization of curve fitting with the calculation of the constant of a spring, and for this purpose we used the statistical tool "Pearson's Correlation Coefficient", with which we obtained a value that shows a moderate correlational tendency between the variables.

Table 2. *Pearson correlation*

Correlations
Pearson's correlation 0.454
p-value 0.001

Source: Test applied to students

Prepared by: Yance Tutiven Cleitton - Córdova López Axel

Once the existence of an average correlation between both variables has been proven, alternatives are sought to teach both contents in the educational environment, and the following are activities that involve the subjects of study.

Conclusions

The problem evidenced in the educational institutions regarding the understanding of the curve fitting technique in the context of determining the elasticity constant of a spring has been effectively addressed through stepwise didactic activities. These activities allowed students to investigate and discuss key concepts such as constants, independent and dependent variables, and the general formula of the linear equation.

The experimental measurement of the spring under different applied forces provided a practical and concrete experience that reinforced the understanding of spring elasticity. Students performed direct measurements of elongations and forces, this activity demonstrated the relationship between the applied force and the stretching or compression of the spring, establishing a solid basis for understanding Hooke's Law. In addition, the variation in spring length as different masses are applied was addressed, exploring how this variation affects the spring constant. Students recognized the influence of mass on the elastic behavior of the spring and analyzed the patterns obtained from the data collected. In other words, the workshop allowed them to establish connections between theory and practice, consolidating previously learned concepts.

The calculation of Pearson's coefficient helped to identify a moderate correlation between the variables of the study and with this, activities involving them were designed, evidencing that the students, through the graphic analysis of the data and curve fitting, were able to visualize and understand the linear relationship between the applied force and the stretching of the spring. The use of tools such as graphs and software for fitting reinforced their analytical skills and their understanding of the theoretical foundations. Finally, a connection was established between the theoretical estimation and the experimental values obtained, allowing them to compare and contrast the results. The application of the theoretical formula to calculate the elasticity constant and the comparison with the averaged experimental values provided a broader perspective on the accuracy of the methods used and the possible sources of error.

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