PREVIOUS CONCEPTUAL KNOWLEDGE IN ENGINEERING STUDENTS FOR THE SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS

W.E. Montaño-Santamaría[1], F. Suarez-Galvis[1], J.L. Vengoechea-Orozco[2], C.R. Vidal-Tovar[3,4], C.A. Severiche-Sierra[4] & Y. Gordon-Hernández[3]

[1]Institución Universitaria ITSA. Barranquilla, Atlántico, Colombia.
wilsonmontano.zharick@gmail.com; fsfsuarez866@gmail.com
[2]Universidad Metropolitana. Barranquilla, Atlántico, Colombia. jvo001@yahoo.es
[3]Universidad Popular del Cesar. Valledupar, Cesar, Colombia.
carlosvidal@unicesar.edu.co; yimygordon@unicesar.edu.co
[4]Universidad de Santander – UDES. Valledupar, Cesar, Colombia.
car.vidal@mail.udes.edu.co
[5]Corporacion Universitaria Minuto de Dios - UNIMINUTO. Barranquilla, Atlántico, Colombia. carlos.severiche@uniminuto.edu.co

ABSTRACT

Conceptual knowledge for the solution of ordinary differential equations in engineering students was identified. It is a quasi-experimental research applied to the educational sciences and technologies, descriptive in nature, using a quantitative approach. The population corresponded to one hundred and ninety (190) students of both sexes enrolled in the first semester of engineering at the ITSA University Institution, located in the city of Barranquilla and Soledad (Colombia), The sample consisted of fifty-three (53) students. The application of the instrument was carried out in sections corresponding to the evaluations of the first partial, second exam and final evaluation. In the instrument, the responses were classified as, leave it blank, it does not do it well, it does it fairly well and Yes it does. The finding indicates that students have a good command of preconceptions. As mathematics articulates the use of these preconceptions or integrates all the knowledge they have acquired around their career performance is not the most expected, this is probably because the cycles in students are not continuous.

Key words: Previous concepts, Differential equations, Mathematics education, University students, Pre-knowledge.

INTRODUCTION

Differential Equations (DE) are a very important part of mathematical analysis and model innumerable processes that lead to a real-life differential equation whereby a valid relationship is given in a certain interval, between a variable and its successive derivatives (Vergel et al., 2018). Its resolution allows studying the characteristics of the systems that are modeled, the same equation can describe processes corresponding to different disciplines (Rodríguez & Quiroz, 2016; Trigueros, 2014).

The E.D., have numerous applications in science and engineering, so that the efforts of the scientists were initially directed to the search for methods of solving and expressing the solutions in an appropriate way (Acevedo, 2018). Thus, the first methods of resolution were algebraic and numerical, which allowed the solution to be expressed exactly, such as y = f (x), a function of the independent variable, and the second aim to calculate values taken by the solution in a series of points which allows that the set of these values is called numerical solution for the estimation of the values in intermediate points can be obtained by interpolation (Molina, 2015; Trejo et al., 2013).

The need to resort to alternative methods and not to algebraic ones is due to the fact that with the exception of a few more or less simple cases, the vast majority of differential equations cannot be satisfactorily solved exactly which leads us (Jaimes et al., 2018).

Various authors point out that the teaching of differential equations in traditional calculus courses is predominantly focused on algebraic solving. As a result of the traditional way of teaching, students develop a limited and restricted vision of this mathematical object (Plaza, 2016; De Las Fuentes et al., 2010).

Learning techniques to determine exact solutions for a very select set of differential equations does not seem to contribute significantly to modeling or interpreting results in terms of the original problem. Furthermore, by neglecting the geometric aspect, students find it difficult to solve problems involving various semiotic registers, understand the meaning of a differential equation, and still recognize them, especially nonlinear ones. For some researchers, the mastery of algebraic techniques constitutes an obstacle to learning through other approaches (Sonzogni, 2017; Espinoza et al., 2016).

The meaning of ordinary differential equations is of fundamental importance for the training of a professional, whether due to the innumerable field of applications or the integrative nature of this theory (Valencia & Gándara, 2018). Being a subject of a four-month subject, with a large amount of content to develop and limited time for learning them, we decided to prioritize that students have a global and more complete idea of differential equations, although perhaps more intuitive and less formal (Estrada et al., 2018). For all that has been exposed in this work, the conceptual knowledge for the solution of ordinary differential equations in engineering students was identified.

MATERIAL AND METHODS

Research Type and Design: This is a quasi-experimental research applied to the educational sciences and technologies, descriptive in a quantitative approach. According to Ruiz (2017), because it is an investigation in the field of education, because it focuses its attention on determining the “what is” of an educational phenomenon and attempts to answer questions about the present state in the field of exact Sciences.

It should be noted that to classify an investigation as experimental it is necessary that at least one of the independent variables studied has been explicitly manipulated by the researchers Portell & Vives (2019) express:

″Experiments with the same group (intrasubject). Each of the participants has received all levels of the independent variable in all orders (complete) or only in one order (incomplete). The effectiveness of this design depends on having controlled the effect of the practice accumulated by the repetition of tasks, so the form used must be indicated, together with the designation. Design with an independent variable, intrasubject, with simple random ordering (complete). In this experimental plan, the nature of the independent variable has allowed many repetitions of each level, so the final presentation of the levels and their repetitions has been done in a simple random way″.

Due to what has been stated above, the sequential quasi-experimental design is considered.

Population and Sample: The population corresponded to one hundred and ninety (190) students of both sexes enrolled in the first semester of engineering at the ITSA University Institution, located in the city of Barranquilla and Soledad. In collecting the data, it was noted that these young people they come from different strata of the city as well as from different municipalities of the Caribbean Coast.

The sample was made up of fifty-three (53) students of the subject of Mathematics of the university institution with ages between sixteen (16) and thirty (30) years, see Table 1. This sample was obtained by applying the following formula (Fong et al., 2017):

$$n = \frac{z^2 NPQ}{(N-1)E^2 + Z^2 PQ}$$

Where

N = Population P = Probability
Q = No probability E = Admitted error

Z = Standardized value (Confidence level)
Sample calculation

Table 1. Sample Calculation

Error	Confidence level	P	Q	$n = \frac{z^2 NPQ}{(N-1)E^2 + Z^2 PQ}$
10%	1,96	50%	50%	112
5%	1,65	50%	50%	128

Source: Own elaboration

As the 10% error is admissible, they will see the sample of fifty-six (56) students.

Instrument: The instrument, a guide to problematic situations, was designed taking into account the topics covered from mathematics in the first semester of engineering and its relationship with the curricular guidelines of mathematics (Gómez et al., 2016), the topics suggested for the application were Ordinary Differential Equations. The observation guide was designed based on the categories observed in the presence of the process of solving problematic situations and at the different moments of variable control.

The application of the instrument was carried out in sections corresponding to the evaluations of the first partial, second parcia and final evaluation, to students who were studying the first semester of engineering, each of which lasted two (2) hours and was carried out in the facilities from the ITSA University Institution. The application of the instrument, for the first and second part, is applied with the intention of carrying out the control over the performance that the participants demonstrate on the mathematical application, as well as the basic elements of mathematics and necessary for the resolution of the EDO

Techniques for data collection: Systematic observations with data collection in record sheets. Following the guidelines of Ballestín & Fàbregues (2019), the observation guide model was subjected to a pilot test that determined its conformity with the research requirements and its relevance within the context of the state of the art and the possibilities of obtaining it. of reliable information. The questionnaire, considered as a tool that facilitates to directly investigate the investigated population, was applied to the selected sample to obtain results and to make an analysis to explain the research variable. In this instrument, the responses were classified as:

1. Leave it blank
2. Doesn't do it well

3. Does it fairly well
4. If you do

RESULTS AND DISCUSSION

It can be seen in Table 2, that 73% of the students have a good handling of the factorization cases, which allows them to have a broader vision of the concepts that are going to be required, it can also be observed that only 70 % of students maintain good management of cases where referral is required. But it was observed that at the time of integration it costs them work since only 61% of the students manage to maintain that level. As it can also be seen that in some cases students derive and integrate better without being clear about the use of factorization, a case that can be understood taking into account that these operations are inverse and almost immediate.

Table 2. Previous Knowledge

	Knowledge					
	Factoring		Derivation		Integration	
	frec	Porc	frec	Porc	frec	Porc
Leave it blank	6	10%	8	13%	12	20%
Does not do well	10	17%	10	17%	11	18%
Does it fairly well	26	43%	28	47%	20	33%
It does well	18	30%	14	23%	17	28%
Total	60					

Source: Own elaboration

The differential equations are according to Rodríguez et al. (2019), a very important part of mathematical analysis, which models innumerable processes that lead to a real-life differential equation through which a valid relationship is given in a certain interval, between a variable and its successive derivatives. Its resolution allows studying the characteristics of the systems that are modeled, the same equation can describe processes corresponding to different disciplines.

Table 3. Knowledge

	Frequency	Percentage	Cumulative Percentage
Leave it blank	8	13,3%	13,3
Does not do well	12	20,0%	33,3
Does it fairly well	27	45,0%	78,3
It does well	13	21,7%	100,0
Total	60	100,0%	

Source: Own elaboration

When performing the analysis in Table 3, it is established that 45% of the students in the group address problems on a regular basis, taking into account the concepts established as requirements for their solution, being consistent with the taxonomy of Marzano and Kendal (Nahón & Urbina, 2019), the evaluated students are in the stage of understanding the knowledge required to solve problems, this cognitive stage of understanding is defined as a process in the cognitive system responsible for translating knowledge into Appropriate ways for its permanent memory storage to occur, that is, to take the structure and format required for key information to be preserved. In this same process and only 21.7% of the students in the group are consolidated with respect to the application of the test.

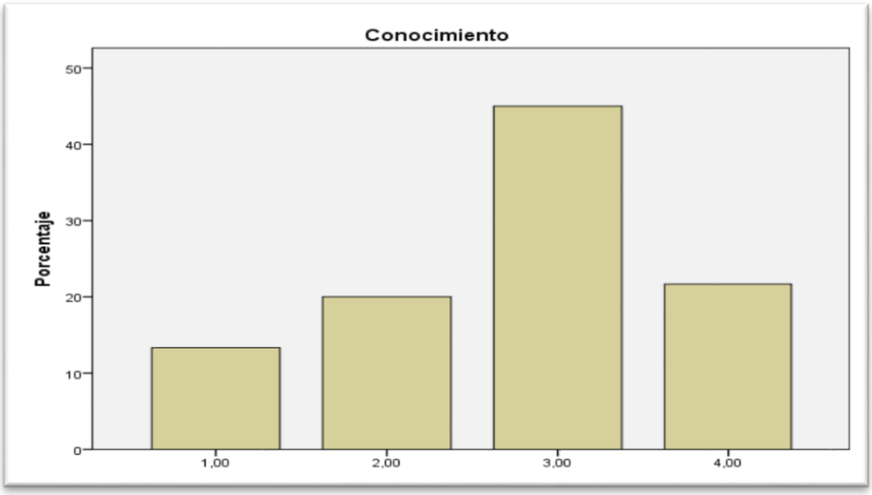

Figure 1. Previous Knowledge

That is, they have a good understanding of the required knowledge that allows them to develop knowledge that they understand. Therefore, it can be affirmed that the analysis goes beyond the identification of the essential versus the non-essential, which are proper functions of understanding (García, 2019). In Figure 1 bar chart, you can see in more detail the analysis presented at the top.

CONCLUSIONS

Taking into account that mathematics is a compendium of knowledge intertwined between topics that students have addressed in previous semesters and in grades of basic schooling, when talking about differential equations we cannot leave aside important concepts such as factorization, derivations and integrations. Given the results, the finding indicates that the students have a good command of the preconceptions. As mathematics articulates the use of these preconceptions or integrates all the knowledge they have acquired around their career, performance is not the most expected, this is probably because the cycles in students are not continuous.

Similarly, this research found that previous knowledge is significantly related to the student's ability to advance his professional training and application of differential equations which is reflected in his academic performance specifically in the areas related to mathematics

REFERENCES

Acevedo, Y. (2018). Modeling in advanced mathematics for engineering. REDIPE Bulletin, 4 (7), 113-119.

Ballestín, B., Fàbregues, S. (2019). The practice of qualitative research in social sciences and education. UOC Publishing.

De Las Fuentes, M., Arcos, J. L., Navarro, C. (2010). Impact on the mathematical competences of the students of differential equations from a didactic strategy that incorporates the calculator. University education, 3 (3), 33-44.

Espinoza, O., González, L., Granda, M. (2016). Regulation in the Higher Education System in Chile: a systemic view considering scopes and levels of execution. H. Lavados and R. Berríos, Policies for university development: principles and evidence, 129-170.

Estrada, I., Jiménez, D., Montenegro, M., Ochoa, J. (2018). Mathematical modeling: a contribution to learning the first order linear ordinary differential equations in engineering. Sigma, 14 (1), 32-48.

Fong, W., Severiche, C., Pitre, R., Vargas, L., Espinosa, E. (2017). Association Between Self-Regulation of Learning, Student Attitude, Provenance and Age in Engineering Students. Contemporary Engineering Science, 10, 665-672.

García, J. (2019). University tutoring as a teaching practice: foundations and methods for developing tutorial action plans at the university. Pro-Posições, 30.

Gómez, P., Castro, P., Bulla, A., Mora, M., Pinzón, A. (2016). Basic learning rights in mathematics: critical review and adjustment proposal. Education and Educators, 19 (3), 315-338.

Jaimes, L., Chaves, R., Vargas, J. (2018). Genetic decomposition as a tool for mathematicians, engineers, and graduates in calculus education: Research in mathematics education. REDIPE Bulletin, 6 (9), 73 -78.

Molina, J. (2015). Experience based on the ICT triad, project teaching and modeling for teaching differential equation systems. University, 29 (2), 46-61.

Nahón, A., Urbina, A. (2019). Theoretical foundations for the transformation of the "Massive Open Online Courses" towards "Customizable Open Online Courses". Edmetic, 8 (2), 129-149.

Plaza, L. (2016). Obstacles present in Mathematical Modeling. Differential Equations Case in the training of Engineers. Scientific Journal, 2 (25), 176-187.

Portell, M., Vives, J. (2019). Research in Psychology and Speech Therapy: Introduction to experimental, quasi-experimental and ex post facto designs (Vol. 60). Publications Servei of the Autonomous University of Barcelona.

Rodríguez, R., Aragonés, N., Calderón, U. (2019). Use of similarity and change of scale to solve some problems posed in terms of ordinary and partial differential equations. Journal of Mathematical Research, 1 (1).

Rodríguez, R., Quiroz, S. (2016). The role of technology in the mathematical modeling process for teaching differential equations. Latin American Journal of Research in Educational Mathematics, 19 (1), 99-124.

Ruiz, S. (2017). Educational research in technological institutes: an experience to develop a state of knowledge. Voices and silences. Latin American Journal of Education, 8 (1), 60-81.

Sonzogni, E. (2017). A Rosario intellectual between the theory of survival of the fittest and humanistic philosophy. The Study on inequality and peace by Juan Ã lvarez. ISHiR Studies, 7 (18), 70-109.

Trejo, E., Gallardo, P., Trejo, N. (2013). Mathematics in the training of an engineer: a methodological proposal. REDU: Journal of University Teaching, 11 (1), 397.

Trigueros, M. (2014). Link between modeling and the use of representations in understanding the concepts of differential equation of first order and solution. Mathematical Education, 207-226.

Valencia, D., Gándara, G. (2018). Sequence of didactic activities to promote the construction of the notion of ordinary differential equation. Calculus and its teaching, Teaching of science and mathematics, 10, 1-20.

Vergel, M., Rincón, O., Zafra, S. (2018). Influence of pre-calculus course on differential equations and development of variational thinking. REDIPE Bulletin, 7 (1), 124-35.