The development of reflective thought for the training in integral people *

El desarrollo del pensamiento reflexivo en la formación de personas integrales *

O desenvolvimento do pensamento reflexivo para o treinamento em pessoas integradas*

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Date Received: February 20, 2018
Date Accepted: May 22, 2018
Date of Publication: July 01 of 2018
DOI: http://dx.doi.org/10.22335/rlct.v10i3.622

* Article research result "Onto-historical understanding of financial math in the trajectory of distance education- Universidad Francisco de Paula Santander´s", research group Zulima Science, funded by the FINU-UFPS Research and Extension´s , co-financing 034-2018.

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Abstract

In this article we present results of research whose objective was to analyze experiences in the growth of plants such as the Duranta and Salvia where the student develops competences in posing and solving problems that allowed him to argue, model, communicate on mathematics in improvement of their academic performance. The methodology followed a quantitative approach, field-type experimental design, applied to a sample of 180 students of engineering programs. Results: 95% of the students remained in the course, 99% scored above the general institutional average in integral calculus. Conclusion: Application in plant growth allowed to develop competences in raising and solving problems, development of mathematical thinking, analyzing variables and changes in a time, modeling situations; argue, represent entities. The use of blogs allowed the generation of new methods of study, and different forms of evaluation and evaluation of learning, both for students and teachers.

Key words: plant growth, critical dialogic approach, integrals, mathematical modeling, mathematical thinking.

Resumen

En el presente artículo se dan a conocer resultados de investigación cuyo objetivo fue analizar experiencias en el crecimiento de plantas como la Duranta y la Salvia donde el estudiante desarrolla competencias en plantear y resolver problemas que le permitieron argumentar, modelar, comunicar sobre las matemáticas en mejora de su rendimiento académico. La metodología siguió un enfoque cuantitativo, diseño experimental de tipo campo, aplicado a una muestra de 180 estudiantes de programas de ingeniería. Resultados: Un 95% de los estudiantes permaneció en el curso, 99% obtuvo nota por encima del promedio general institucional en cálculo integral. Conclusión: Aplicación en crecimiento de plantas permitió desarrollar competencias en plantear y resolver problemas, desarrollo del pensamiento matemático, analizar variables y cambios en un tiempo, modelar situaciones; argumentar, representar entidades. El uso de blogs permitió la generación de nuevos métodos de estudio, y diferentes formas de evaluación y coevaluación del aprendizaje, positivas tanto para estudiantes como profesores.

Palabras clave: crecimiento de plantas, enfoque dialógico crítico, integrales, modelado matemático, pensamiento matemático.

Abstrato

Neste artigo apresentamos resultados de pesquisa cujo objetivo foi analisar experiências no crescimento de plantas como a Durana e a Salvia, onde o aluno desenvolve competências em colocar e resolver problemas que lhe permitiram discutir, modelar, comunicar sobre matemática na melhoria de suas habilidades. performance acadêmica. A metodologia seguiu uma abordagem quantitativa, do tipo experimental de campo, aplicada a uma amostra de 180 alunos de programas de engenharia. Resultados: 95% dos alunos permaneceram no curso, 99% pontuaram acima da média institucional geral no cálculo integral. Conclusão: A aplicação no crescimento de plantas permitiu desenvolver competências no levantamento e resolução de problemas, desenvolvimento do pensamento matemático, análise de variáveis e mudanças em um tempo, modelagem de situações; argumentar, representar entidades. O uso de blogs permitiu a geração de novos métodos de estudo e diferentes formas de avaliação e avaliação da aprendizagem, tanto para alunos como para professores.

Palavras-chave: crescimento vegetal, abordagem dialógica crítica, integrais, modelagem matemática, pensamento matemático.

Introduction

The application of the calculation allows orienting knowledge in topics and content proposed in the micro-curriculum of integral calculus, in addition, it facilitates the analysis of results in the development of cross-sectional projects through field work integrating students to research, who learn to predict incremental processes and decrease, by using equations, limits, changes from one variable to another, identify the behavior of a growth and decrease equation based on real situations experimentations in our environment (Martinez, Vergel & Zafra, 2015). This dynamic and the methodology proposed through interaction and dissemination of results through blogs strengthened teamwork, as well as the interrelation between different areas in search of interpreting results and generating mathematical models (Vergel, Rincon & Jaimes, 2016).

Theoretical Foundation

Vázquez (2012) pointed out that an engineer is the one who, with the available resources and knowledge, provides useful creations to society; He adds that there is a notable gap between his knowledge and what the country needs. In that sense, Vergel, Parra, y Zafra (2016) agree in indicating that students should be provided with a general and well-integrated view of engineering (functions, methods and context) that allows them to become aware of the knowledge and the additional skills that they must learn later in the professional practice.

Population growth or population dynamics was one of the first attempts to mathematically model human population growth, this is how the economist Thomas Malthus in 1798 analyzed the hypothesis where the population growth rate with constant birth and mortality rates, grows proportionally (two quantities u and v are proportional, then u α v, that is, one quantity is a multiple of another, then u = kv). For the case of the total population P (t) of the country at any time t, the variation of the population with respect to time is given by equation (1):

$$\frac{\mathrm{dP}}{dt} = \mathrm{kP}, \quad \text{where k is a proportionality constant} \quad (1)$$

When looking for the equation that gives rise to the differential equation when deriving it with respect to time, the opposite operation is applied to the derivation, that is to say the integration, for which variables are separated obtaining the expression (2) - (4):

$$\int \frac{dP}{P} = \int k dt, \qquad Ln|P| = kt + C \qquad (2)$$

$$e^{LnP} = e^{kt+C} = e^{kt}e^{C} \qquad (3)$$

$$P(t) = e^{kt+C} = e^{kt}e^{C} \qquad (4)$$

Let P_0, be the initial population quantity, that is, at a time t = 0,

$$P(0) = e^{k*(0)}e^{C} = e^{C} = P_0 \qquad (5)$$

$$P(t) = P_0 e^{kt} \qquad (6)$$

P (t) is the general solution of the differential equation, in which a family of curves is observed according to the initial value P_0. K indicates the rate of variation of P with relation to t, if the constant of proportionality k, y, P (t) are positive, then P '(t) is positive and P (t) is increasing, in this case it is said that the problem is growth. But, if k is negative, and, P (t) is negative, then P'(t) will be negative, which implies that P (t) is decreasing, and the problem is of decrease.

On the other hand, the analysis of plant growth is a technique widely used today and is very useful to analyze the performance in terms of growth. The growth of a plant or one of its organs can be studied by measuring variables such as length, volume, fresh or dry weight, among others, at successive intervals of time during the development period. By plotting the results of these measurements as a function of time, a sigmoid curve can be obtained, and it is always possible to find a non-complex mathematical function that reproduces growth with considerable accuracy (Hewitt, 2013). Some growth phases of organisms are usually in accordance with the exponential function.

Growth curves reflect the growth behavior of a plant in relation to time and are governed by external or environmental factors and internal factors of the plant that may have a genetic basis. The action and interaction of these factors allows the development of the plant, presenting an association between the factors of growth and performance (Vergel, Martínez & Zafra, 2017).

The authors agree that growth constitutes an irreversible increase in the size of the plant,

associated with an increase in dry weight, without neglecting, differentiation, or increased complexity of the plant, reserve the term growth for the quantitative aspects of development and the differentiation for the qualitative aspects of it. In reality, it is very difficult to isolate such processes on a higher floor due to their close interaction. When basic structural units are increased by cell division, they also increase their size, fresh weight, dry weight or volume.

Methodology

The research follows a quantitative approach of a descriptive type, with a quasi-experimental design, using data collection to test hypotheses, based on numerical measurement, and statistical analysis, so that behavior patterns can be established (Martínez, Vergel & Zafra, 2016). The research was carried out during the second semester of 2015 and the first of 2016, in a population made up of 180 students of integral calculus.

The sample distributed in two groups, group A, formed by students of systems engineering, civil and mechanical engineering (classes that develop experimentation); the group B control conformed by students of industrial engineering, environmental and mining engineering. In Group A, three moments were developed, an initial moment that consisted in developing a simple experiment controlling variables and taking into account height and time, modeling equation and comparing with text data (Vergel, Martínez & Nieto, 2016); a second moment they develop a growth experiment of another species taking into account variable temperature, height time, weight, elaborate and compare mathematical models through analysis and hypothesis testing.

The mathematical thinking development test proposed by Vergel, Duarte and Martínez (2015) is applied. Each student links videos explaining results of their experiences and exhibitions of integral calculus curriculum topics (Rincón, Vergel & Zafra, 2017). To analyze satisfaction in the use of the blog by the experimental group, rubrica was used (Rincón, Vergel & Ortega 2015).

Results

Test of normality group control and group test

Table 1.

Normality test pre-test development of mathematical thinking

Grupo	Media	Desviación estándar	Kolmogorov-Smirnov			Shapiro-Wilk	
			Statistic	gl	p	Statistic	P
Grupo A Prueba	2,1	0,67	0,193	179	0,061	0,912	0,26
Grupo B Control	2	0,38	0,182	179	0,14	0,865	0,29

Source: Authors

In Table 1, it can be seen that none of the groups approved the average score of the diagnosis (0.0-5.0), obtaining the best average group B. Performed Chi-square test, p> 0.05 indicating that the variable tested and group are independent, that is, the results did not depend on the way in which the groups were selected. In the Smirnov-Kolmogorov test each value p> 0.05, it is then accepted that the groups are normally distributed. In the variance homogeneity test with Levesne statistic p> 0.05, assuming that the variances are equal for the groups. Once these assumptions have been verified, a "t" test is performed to compare means with p> 0.05, so there is no evidence to suggest that the groups differ from each other.

Start-up experience Moment 1. Growth in Duranta

The study of the growth of a Duranta Adonis plant, according to the manifest by Kang et.al (2014) of the Verbenaceae family, genus Plantae,

planted in the city of Cúcuta. Duranta is a shrub that reaches a size of 2 m to 4 m high, with thorns or frequently unarmed. Its opposite, simple, obovate-spatulate to elliptical, 3.2 cm to 7 cm long and 1.5 cm to 3 cm wide, acute (a rounded) apex, attenuated base, entire margin or with few irregular teeth in the upper half leaves, glabrescentes. The inflorescence in clusters of 5 cm to 22 cm in length, terminal and axillary, sometimes presenting as panicles, frequently recurved or pendulous, bractéolas 3 mm to 4 mm long; corolla zigomorph, more or less hypochloreiform, blue, lilac or white, with narrow tube 7-10 mm long, 5-lobed, unequal wolves 3 mm to 5 mm long; druceous fruit, pyrenes 4, each with 2 seeds, to which a data collection was made (figure 1), taking the height according to the elapsed time as study variables.

Figure 1. Sowing and data collection Duranta
Source: Authors

Using the Excel tool, they generate the graph of time vs. length of a branch (Figure 2).

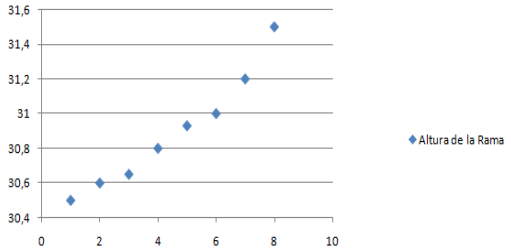

Figure 2. Duranta plant growth data in eight days
Source: authors

Then analyze the relationship and correlation index between variables, obtained the function that described the growth of the plant

$$y = 30{,}30e^{0.004x}$$
$$R^2 = 0{,}951$$

The equation (7) that described the variation of growth of the branch of the Duranta plant, h, according to the change in time t, was given by

$$\frac{dh}{dt} = 0.1212e^{0.004t} \qquad (7)$$

Comparing and determining data for initial t time and t time corresponding to one day: Initial general: h (0) = 30.3 cm, For Time (1 day): h (1) = 30.5 cm $\frac{5033}{5000}$h (0)

For this experiment, the increase in the measurement time was 0.66%. Comparing data using text growth formula:

We have $h(t) = ce^{kt}$, Where $h(0) = c$ then $h(t) = h(0)e^{kt}$
Where $h(1) = \frac{5033}{5000}h(0)$ then $\frac{5033}{5000}\ h(0) = h(0)e^{k}$
$e^{k} = \frac{5033}{5000}$ This is $k = \ln\left(\frac{5033}{5000}\right)$, $k = 0.0065$ $then$
$h(t) = h(0)e^{0.0065t}$ (8)

Table 2.

Analysis performed by students comparing experimental data and according to text equation.

	Time 1	Time 3	Time 6
Original ED.	30.42(30.5)	30.66(30.65)	31.03(30.31)
ED. Of texts	30.49(30.5)	30.89(30.65)	31.50(30.31)

Source: Student results

The equation generated by students shows, E1 "is more accurate than the differential equation of the texts", because in the texts do not take into account many important growth factors, which vary the values obtained and generate results with less accuracy.

Analysis of student academic performance results

There are indications to assume significant differences in average final grades between control group B and test group A (Table 5). Similarly, there are indications to assume significant differences in mathematical thinking test results between the control group B and the test group A. On the other hand, weighted average analysis in calculation shows significant differences in the general institutional average (mean = 3.2) and average of experimental group students (mean = 4.4), p <0.05. Analysis of student desertion shows that only 1% of the students defected in the experimental group courses.

Table 3.

Test t for difference of half independent samples final note.

Test for equality of variances	Media	Standard deviation	F	P	t	p value	Average difference	95% interval Lower	Upper
Group A Proof	4,4	0,519	1,024	0,267	2,86	0,008	0,298	3,19	4,89
Group B control	2,5	1,068	0,122	0,629	1,96	0,048	1,624	1,00	3,61

Source: Authors.

With a significance level of 0.004 the bivariate Correlational analysis shows high correlation between variables, proof of mathematical thinking development and learning abilities (0.9). The development of competences following a dialogical critical approach situates the teaching and learning of calculus, as an enhancer of social practice, of innovation, of self-training, for which the didactics of mathematics today install new redefinitions and challenges.

Also determining the importance of the impact of the use of the blog in the teaching - learning of the integral calculus (Rincón & Vergel, 2015), where the degree of interest on the part of the students is evidenced, the adoption of study routines independently, the promotion of self-learning and its pedagogical value, reflecting all these factors in the better understanding of concepts, procedures and their applications to real contexts, improvement in the didactic quality of the classes received and availability of alternative resources for teaching (Vergel, Rincon & Martinez, 2016), which finally translate into a better academic performance of the students that solidifies the inter-linking of the subject's curricular, with other related in the curriculum, with a significant contribution to the personal and professional profile of the student.

Conclusions

The application and development of growth experiments through plants, for the teaching of the calculus showed favorable incidences in the academic performance and in the development of

the mathematical thinking of the students of the experimental group.

Application in growth of plants allowed to develop competences in raising and solving problems, development of mathematical thought, analyzing variables and changes in a time, modeling situations; argue, represent entities, and communicate about mathematics. The use of blogs allowed the interaction and active participation of students in the course, the generation of new study methods, exchange results with students from other academic programs and linking students from external institutions.

Students made evaluation of content, experience and participation through virtual blog and the co-evaluation of learning through essays, constituting a positive experience for students and teachers.
The students were able to improve general, procedural, conceptual and social competences, they show achievements in solving problems, situation analysis, error control, argumentation, mathematical, technological and communicative thinking.

Students who perform mathematical models from the experimentation of plant growth, show greater sense of success, feel competent to analyze results.
Plant growth theme was the most significant for the students, its incorporation into the methodology as an activity and the use of blogs as a tool allows to comply with the content proposed in syllabus, as well as enhances team work and the relationship between different areas.

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