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Dynamic analysis, Existence and stability conditions of equilibrium, Computational techniques, Miscellaneous mathematical tools, Input-Output models, Computable general equilibrium models; Game theory and bargaining theory: Cooperative games, Noncooperative games, Stochastic and dynamic games, Bargaining theory, Matching theory; Data collection and Data estimation methodology: Computer programs, Methodology for collecting, Estimating, and Organizing microeconomic, Methodology for collecting, Estimating, and Organizing Macroeconomic Data, Econometric software; Design of experiments: Laboratory, Individual behavior, Laboratory, Group behavior, Field experiments and other topics related to Social Sciences.

Presentation of the Content

In the first chapter we present, *A virtual learning environment for a remedial differential calculus course*, by AGUILAR-SALINAS, Wendolyn Elizabeth & DE LAS FUENTES-LARA, Maximiliano, with adscription in the Universidad Autónoma de Baja California, as a second article we present, *Level of competence on the concept of basis of vector space using SOLO taxonomy*, by VALENZUELA-GONZÁLEZ, Verónica, HERNÁNDEZ-QUINTANA, Andrés and CAMACHO-RÍOS, Alberto, with adscription in the Tecnológico Nacional de México campus Chihuahua II, as the following article we present *Method of typification of the growth curve of the Andean guinea pig with the logistic model,* by MARTÍNEZ-GONZÁLEZ, Sergio, PEÑA-PARRA, Bladimir, MORENO-FLORES, Luis Antonio and MACÍAS-CORONEL, Humberto, with affiliation at the Universidad Autónoma de Nayarit, as next article we present *Educational application based on MATLAB for the analysis of transient stability of power systems*, by GARCÍA-GUZMÁN, José Miguel, ARREOLA-AGUILAR, Miriam Ivonne, GONZÁLEZ-PONCE, María del Refugio and SOTO-MORALES, José Luis, with affiliation at the Instituto Tecnológico Superior de Irapuato.

Content

Article **Journal-Mathematical and Quantitative Methods**
June 2021, Vol.5 No.8 1-9

A virtual learning environment for a remedial differential calculus course

Un ambiente virtual de aprendizaje para un curso remedial de cálculo diferencial

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Abstract

Information and communication technologies have led to the development of new learning modalities and techniques. This research is based on the design of a remedial course for the subject of Differential Calculus and its corresponding method of evaluation in a virtual learning environment, which allows the student practical and autonomous learning. Its elaboration consists of two parts: the instructional design associated with the learning topics identified as necessary for the learning of the Differential Calculus and the evaluation method for the achievement of the learnings. This course is expected to assist the student in the possible learning lags of the Differential Calculus to successfully complete the Integral Calculus learning unit.

VLE, Differential Calculus, Instructional Design, Evaluation Methods

Resumen

Las tecnologías de información y comunicación han propiciado el desarrollo de nuevas modalidades y técnicas de aprendizaje. Esta investigación se basa en el diseño de un curso remedial para la materia de Cálculo Diferencial y su correspondiente método de evaluación en un ambiente virtual de aprendizaje, que le permite al estudiante un aprendizaje práctico y autónomo. Su elaboración consiste de dos partes: el diseño instruccional asociado a los tópicos de aprendizaje identificados como necesarios para el aprendizaje del Cálculo Diferencial y el método de evaluación para el logro de los aprendizajes. Se espera que este curso ayude al estudiante en los posibles rezagos de aprendizaje del Cálculo Diferencial para culminar con éxito la unidad de aprendizaje de Cálculo Integral.

AVA, Cálculo Diferencial, Diseño Instruccional, Métodos de evaluación

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Introduction

The academic performance of students entering engineering careers is low, which makes it difficult to learn Differential Calculus (CD) and results in failure of the subject and school dropout (López, 2005). In some institutions in the country, the failure rate for CD is 80% and approximately 40% are forced to leave their studies due to failure for the third time (Riego, 2013; Pineda, 2008).

The learning unit (UA) of CD is located in the common core of engineering sciences, within the basic stage at the Autonomous University of Baja California (UABC). This provides the bases or principles of topics such as inequalities, functions, limits, derivation and optimization, by developing in the student the skills, tools, knowledge, aptitudes, attitudes and values for the effective application of mathematics in engineering. Its objective is to provide students with knowledge that allows them to interpret, pose and solve engineering problems (Zúñiga, 2007), since the training of engineers demands mathematical learning that contributes to solving specific problems of a technological nature, but above all practical (Ruiz, Carmona and Montiel, 2016).

With the social distancing caused by COVID19, basic, middle and higher education institutions in Mexico have had to migrate to a new learning modality: online or virtual. The advantages of this modality can be summarized in five different areas: flexibility in the distribution of topics, variability in the times of each objective, flexibility in study time, greater interest in learning and the opportunity to interact and explore the topics through the use of simulators (Vasquez, 2020).

Within the UABC, the Center for Open and Distance Education (CEAD) is the body responsible for providing institutional administration services for online courses, either in the blended or distance mode, which began in the 2012 semester. 2 and included activities associated with teacher training, instructional design (DI) and evaluation methods (Avitia, Candolfi, Arellano & Uriarte, 2014). Within these activities the development of ID deals with: the planning, preparation and design of the resources and environments necessary for learning to take place (Bruner, 1969).

The instructional designer (teacher), in this case, will have to transcend the merely communicative aspects of the process to attend to the coherence and relevance of the contents, the objectives and the learning activities, which arise as an alternative to the questionnaires and make evident the concern to make the participation of students more active in the learning process (Chiappe, 2008), by having a broader, flexible and focused vision on the generation of general spaces and not on the development of specific strategies (Umaña, 2009).

The first instructional designs developed for the Mexicali School of Engineering (FIM) were completed in the 2016-1 school year and began to be used in the 2016-2 school year for semi-presential UAs. The Differential Calculus UA was not alien to this process, being implemented in a blended way. In the course of the 2016-2 to 2019-2 school cycles for this UA, no significant differences were found in the students' evaluations according to the learning modality.

Assuming that the effectiveness of an educational process is not in the modality in which it is taught, but in the pedagogical approaches, and based on the fact that there are no significant differences between the results obtained in the teaching of classes in face-to-face or online modality (García, 2017), a remedial course of the UA of CD was designed for the students of the Faculty of Engineering Mexicali (FIM) of the UABC during the period 2021-1 through a virtual learning environment (AVA) with the Blackboard learning management system.

The remedial course of Functions and Derivatives will provide the student with the knowledge, methods and techniques, by favoring in the student critical reasoning, creativity, teamwork and interest in searching for information and solving problems.

Objective

Design a remedial course for the matter of Differential Calculus called Functions and Derivatives in the online mode, in accordance with the guidelines of the UABC educational model, as well as the corresponding academic model.

Theoretical framework

VLEs are educational practices that operate, develop and take place on the Internet, and that allow communication between users (Coll and Monereo, 2008) in an effective and constant way, obeying the pedagogical principles that guide the development of the themes established for the learning (Dillenbourg, Schneider and Synteta, 2002), creating new spaces for collaboration between teachers and students, overcoming the traditional paradigms of teaching, impacting on the achievement of learning (Brioli and Garcial, 2011; Betegón, et al., 2012 ; Osuna and Abarca, 2013).

Therefore, López, Ledesma and Escalera (2009, p. 6) mention that: “A Virtual Learning Environment is the set of synchronous and asynchronous interaction environments, where, based on a curricular program, the teaching-learning process, through a learning management system”.

For the construction of this VPA, the use of a DI was necessary, as a systemic, planned and structured process that must be carried out to produce courses in the face-to-face or virtual modality, it is based on learning theories and goes from the definition from what the teacher wants the student to learn until the formative evaluation of the process (Agudelo, 2009). If ID is based on a constructivist approach, the teacher or learning designer is required to produce programs and materials of a much more facilitating than prescriptive nature (Guàrdia and Sangrà, 2005). In the same way, a change of pedagogical vision is required, which includes a change of roles and functions, to transcend the traditional model of instructional design, for another that demands greater flexibility and openness in the student's learning processes (Umaña, 2009).

Therefore, constructivist theories seem more appropriate for new educational contexts and offer more opportunities to design training actions that allow the achievement of professional skills, since as the learner is capable of interpreting multiple realities, he is better prepared to face situations of the real life. If a student can solve problems, he will be better prepared to apply his knowledge to new and changing situations (Guàrdia and Sangrà, 2005).

The models of constructivist instructional designs in distance education require technological supports, since they provide a series of tools that allow the student to become an active participant in the learning process, thus transcending the use of materials printed, to incorporate other types of media that are required for learning processes (Umaña, 2009).

Methodology

For the development of the VLE, it was necessary to develop a DI that will guide the sequence of learning activities, as well as evaluation methods to identify learning achievements.

Instructional design

The ID used is based on constructivist theories, so it tends for the designer to discover the best combination of materials and activities that guide the student to realize the value of their cognitive construct for future learning. This DI has four stages of a flexible system in which the stages are not sequential, but in a certain way simultaneous and influence each other, in which it is found: analysis, design, production, implementation and continuous review (Córica, Portalupi, Hernández and Bruno, 2010).

The first activity developed within the development of the DI was the general description of the course (Table 1), in this the generalities of the course are established, such as: name, password, academic level, validity of the study plan, academic programs in the that is taught, school year, credits, formative stage, nature of the subject and modality. As well as, the answer to the following questions, which will describe the development of the course in the blended mode: What will the student learn during the course? Understanding both the general competence and the general purpose of the course, how will the student learn? In which the general learning strategy is explained, how will you know she learned it? For this, the criteria, the general strategy of the course and the performance evidence were established.

Course overview		
1.	Name of the subject.	Functions and Derivatives
2.	Academic level (s) at which it is taught.	Bachelor's degree
3.	Unique key of the course.	Does not apply
4.	Validity of the plan to which the subject corresponds.	2019-2
5.	Academic program (s) and academic unit (s) in which it is taught.	Common Core of: Civil Engineering, Electronic Engineering, Aerospace Engineering, Mechatronics Engineering, Industrial Engineering, Bioengineering, Renewable Energy Engineering, Mechanical Engineering
6.	School cycle.	School period in which it is taught
7.	Credits and Total hours.	Does not apply
8.	Formative stage.	Common Trunk
9.	Recommended profile of the participants.	Be taking the Comprehensive Calculus learning unit.
10.	Nature of the subject.	Voluntary
11.	Instructional Modality	Online
12.	What will the student learn during the course?	**General competence:** Apply the concepts and procedures of calculus in the differentiation of functions, through the use of limits and derivation theorems, supported by information technologies, to solve everyday problems, science and engineering, with a disposition for collaborative work, respect and honesty.
		General purpose: The content of this Learning Unit contributes to the training of the student and future engineer, provides the bases (principles) of topics such as inequalities, functions, limits, derivation and optimization, developing in the / the student, the various skills, tools, knowledge, attitudes, aptitudes and values for the effective application of mathematics in engineering, with a critical, objective, responsible and purposeful attitude for the correct application of Differential Calculus in real situations, in such a way that generates mental constructions capable of providing correct solutions in topics that will be addressed later in the learning units of the basic, disciplinary and terminal stage, according to the profile indicated by their respective Educational Program, among which could be mentioned, Comprehensive Calculus, Equations Differentials, Heat and Mass Transfer, Static, Dynamic, Electricity and Magnetism, Electric Circuits, among others.
13.	How will the student learn? (General learning strategy of the course).	General learning strategy: Through the study of the didactic material provided by the teacher, as well as the knowledge acquired through research and practical activities related to the topics that will be developed during the course. The student will use and reinforce the knowledge and skills acquired in his differential calculus course, will show attitudes of commitment, responsibility, ethics, a taste for research, as well as a self-taught sense.
14.	How will you know you learned it? (Criteria and Evidence of performance, Course level).	Performance evidence: In each unit the goals and requirements of each one are specified, just as in each goal the product that must be delivered is specified for the student to apply what they have learned. Accreditation criteria: ● Presentation of surveys.
15.	Name and value of the Learning Units incorporated into the course.	Each of the goals contains specific criteria against which the student will be evaluated. Each goal / practice has a percentage value in the overall grade. Evaluation: Unit 1. Functions of a variable. ● 1 week 25%. Unit 2. Limits and continuity. ● 1 week 25%. Unit 3. The derivative. ● 1 week 25%. Unit 4. Application of the derivative. ● 1 week 25%.
16.	Support materials: readings, exercises, formats and sites, by Unit.	* MANUALS: Own elaboration manual. * BOOKS: Boyce, W. and Diprima, R., (1994). Calculus (First edition) Mexico. Ed. CECSA. Howard, A., (1991). Calculus and Analytical Geometry (First edition). Mexico. Ed. LIMUSA Larson, R., Hostetler, R. and Edwards, B., (1995). Calculus and Analytical Geometry (Fifth edition). Spain. Ed. Mc Graw Hill. Leithold, L., (1992). Mathematics prior to calculus (Third edition). Mexico. Ed. Oxford. Leithold, L., (1992). The Calculus (Seventh Edition). Mexico. Ed. Oxford. López, I. and Wisniewski, P., (2006) Differential Calculus of a variable with applications (First edition). Mexico. Ed. Thomson. Purcell, E., Varberg, D. and Rigdon, S., (2001). Calculus (Eighth Edition). Mexico. Ed. Pearson Education. Smith, R. and Minton, R., (2000). Calculus Volume 1 (First edition). Colombia. Ed. Mc Graw Hill. Stewart, J., (2006). Calculus, Concepts and Contexts (Third edition). Mexico. Ed. Thomson. Swokowski, E., (1989). Calculus with Analytical Geometry (Second Edition). Mexico. Ed. Grupo Editorial Iberoamérica. Thomas, G. and Finney, R., (1998). I calculate a variable (Ninth edition). Mexico. Ed. Addison Wesley Longman. Zabala, A., and Arnau, L., (2008). 11 Key ideas, How to learn and teach skills? Barcelona. Editorial Grao. Second edition. *SOFTWARE GEOGEBRA (www.geogebra.org/).
17.	Course enrollment, operation and evaluation policies.	I will be on time for face-to-face or chat sessions. I will have an appropriate and respectful language when I communicate with my classmates or teacher. I will review weekly the material that the teacher has uploaded to the platform. I will make sure that my participation in the activity, forum or evaluation has been recorded. Feedback will be made through the medium that is being used (forum, evaluation, activity).
18.	Name and email of the owner or owners of the course.	Wendolyn Elizabeth Aguilar Salinas aguilar.wendolyn@uabc.edu.mx Maximiliano De Las Fuentes Lara maximilianofuentes@uabc.edu.mx
19.	Names, email, municipality and faculty of the technical support staff.	Aglay González-Pacheco Saldaña aglay@uabc.edu.mx Faculty of Engineering, Campus Mexicali.
20.	Authors, dates of elaboration and last update.	Preparation of the Instructional Design in Online Mode (January-2021) • D.C. Wendolyn Elizabeth Aguilar Salinas • D.C. Maximiliano De Las Fuentes Lara

Table 1 Course overview
Source: Self-made

Once these needs have been identified, educational goals are established, which will be achieved if the participants assimilate and put into practice the acquired knowledge (Gil, 2004; Gutiérrez, 1997), which must be aimed at the situations that students will have to face, making timely decisions that provide the best resources to achieve them (Escontrela, 2003). Corica et al. (2010) consider that it is essential for the learning process to have objectives to achieve, goals to meet, for which motivation and interest are essential.

Therefore, the second activity was the development of the goals, in which the goals to be achieved and the means to achieve them had to be clearly planned (Gil, 2004). Table 2 shows the construction of the goals of the first unit as an approach to the general map of the course, for which 15 goals were designed that would cover the main topics of the Differential Calculus UA. Each of the goals describes its scope, value and activities to be developed by the student.

Diagnosis of algebraic, geometric and trigonometric skills	
Goal	**Activity**
Goal 0: Diagnosis Value of this goal 0%	Carry out the Diagnosis on algebraic, geometric and trigonometric skills. No later than February 26, 2021 at 11:59 p.m. Use only pencil, paper and scientific calculator.
Course: Functions and Derivatives **Competence:** Apply the concepts and procedures of calculus in the differentiation of functions, through the use of limits and derivation theorems, supported by information technologies, to solve everyday problems, science and engineering, with a disposition for collaborative work, respect and honesty.	
Unit 1: Functions of a variable Identify the various types of functions, through their different representations (graphical, numerical and analytical), for use in the derivation and modeling processes, with active, analytical and proactive participation.	
Goal	**Activity**
Goal 1.1: Solve the different types of inequalities through the use of the appropriate theorems. Value of this goal 2%	Read the support material. Review the web pages. It is suggested to prepare the exercises proposed in this goal and participate in the survey no later than February 22, 2021 at 11:59 p.m.
Goal 1.2: Interpret the concept of function and its different representations, as well as its classification. Value of this goal 5%	Read the support material. Review the web pages. It is suggested to prepare the exercises proposed in this goal and participate in the survey no later than February 22, 2021 at 11:59 p.m.
Goal 1.3: Identify the algebraic functions, as well as interpret the changes from the modification of parameters, displacements, stretching and reflections. Value of this goal 8%	Read the support material. Review the web pages. It is suggested to prepare the exercises proposed in this goal and participate in the survey no later than February 22, 2021 at 11:59 p.m.
Goal 1.4: Obtain the operations of addition, subtraction, multiplication and division between functions, as well as the composition and inverse of a function. Value of this goal 6%	Read the support material. Review the web pages. It is suggested to prepare the exercises proposed in this goal and participate in the survey no later than February 22, 2021 at 11:59 p.m.
Goal 1.5: Distinguish characteristics of transcendent functions such as their period, domain, range, as well as their representations. Value of this goal 4%	Read the support material. Review the web pages. It is suggested to prepare the exercises proposed in this goal and participate in the survey no later than February 22, 2021 at 11:59 p.m.

Table 2 General map of the course
Source: Self-made

The goals set for each unit of the UA descriptive letter were described based on three questions. What do I need to have at my disposal? What steps should I take? and How will I know that I achieved the goal? Next, the description of goal 1.1 is shown in table 3 as an example, showing the sequence that each activity must take to achieve the objectives set.

On platform (week 1)
First. Review the following material that is available for this goal. **Goal 1.1 Solve the different types of inequalities through the use of the appropriate theorems.pdf**
Second. Make a documentary search, in reliable sources where you can find more information on this topic. You can also consult the following link, to have a clearer idea of the resolution of inequalities. Video-Linear inequalities Video-Inequalities with absolute value
Third. It is suggested that you elaborate the proposed exercises. **Goal 1.1 Task-Solve the different types of inequalities through the use of the appropriate theorems.pdf**
Bedroom. Participate in the survey, you find it as Goal 1.1 Survey-Inequalities
► **Expiration / delivery dates:** ● Goal 1.1 Survey-Inequalities no later than Monday, February 22, 2021 before 24:00.
► **Learning reflection | How will I know that I have achieved the goal?** ● I know the classification of real numbers. ● I know the different types of intervals. ● I classify real numbers as rational or irrational. ● I solve linear and absolute value inequalities.
Evaluation criteria: **Survey-Inequalities (2%).** **Goal 1.1 is equivalent to 2% of your final grade for the Functions and Derivatives course.**

Table 3 Goal 1.1 content
Source: Self-made

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Evaluation method

The evaluation method was designed through surveys, which evaluated each of the goals of the course. To construct each survey, the Nitko (1994) model was adopted to develop curriculum-oriented exams. This model is complemented by the methodology for the construction of criterial tests of Popham (1990) and with methodological and operational contributions of Contreras (1998, 2000). The quality analysis of the measuring instrument is done according to the Classical Test Theory (TCT), so that the designed instrument allows to measure the abilities of the students in the developed subject.

A quality analysis of the instrument was developed through content and criteria validity. The validity of the content is guaranteed from the selection of appropriate indicators related to mathematical processes and the contrast of the validity of the reagents through the judgment of experts (Alsina and Coronata, 2014). In this type of validity, a panel of expert judges with at least 5 years of seniority in the subjects object of the validation is selected who must analyze the coherence of the items with what is to be evaluated, the complexity of the items and the ability cognitive to be evaluated (Barrazas, 2007) as well as the sufficiency and relevance of the reagents, considering the aspects of the construct that are relevant, included in the competencies and indicators (Cisneros, Jorquera and Aguilar, 2012).

Each survey designed aims to verify the knowledge or mastery of the students regarding the contents or topics of differential calculus that are considered necessary in engineering programs. In order to determine if the measurement instrument reagents truly examine the topics and indicators of achievement established in the design specifications, a review was carried out with a team of 5 judges, university professors from the area of mathematics with a master's degree or PhD and outside the process of design and construction of the measuring instrument.

The survey was designed based on clear specifications for each item, including: competence, indicator, content type, difficulty, instructions to answer the item, item base, distractors, correct answer, sample item, estimated execution time, and congruence with the competition.

Likewise, 30 items were built for each of the surveys, items aligned with the curriculum and multiple choice were built, from which the Blackboard platform randomly selects 10 items for each student.

The general indices considering the 15 surveys applied to the students are observed in Table 4, where it is evident that each item is well discriminated and that the difficulty ranges between 15% and 97% with an average of 69%, which means that the makes it ideal to apply to large masses.

	Discrimination index	**Difficulty index**
Minimum	0.15	0.15
Maximum	0.78	0.97
Rank	0.63	0.82
Half	0.52	0.69
Standard deviation	0.11	0.17

Table 4 Percentages associated with the construction of the surveys
Source: Own elaboration

The surveys carried out are considered as a criterial test by virtue of the fact that it is intended to determine mathematical abilities and support the integral calculus course. The Difficulty Index (ID) is related to the proportion of students who correctly solve an item, and is calculated according to Crocker and Algina (1986). There are parameters for the acceptance of a reagent according to its level of difficulty, the one established by Contreras, Backhoff and Larrazolo (2004), says that it must be greater than 0.05 and less than 0.95, for the TCT this index must be between 0.1 and 0.9. According to Backhoff, Larrazolo and Rosas (2000), the average level of difficulty of the instrument should range between 0.5 and 0.6, distributing the values of the difficulty index as follows: 5% of highly easy items (0.87 <ID <1), 20% moderately easy (0.74 <ID <0.86), 50% with a medium difficulty (0.53 <ID <0.73), 20% moderately difficult (0.33 <ID <0.52) and 5% highly difficult (ID <0.32).

The discrimination index (IDC) of the item allows differentiating (discriminating) between students who obtained high scores in the test and those who obtained low scores, and is related to the high possibility of answering the item correctly those students with a general performance outstanding in the test, opposite situation in the case of students with a poor performance, in this analysis 54% of the sample population is considered, since 27% of the students with high performance and the same percentage of students are included with the lowest yield, for each reagent that is reviewed. For Contreras, Backhoff and Larrazolo (2004) and for TCT, the discriminative value of the reagent is considered appropriate if it is greater than 0.2. According to Guilford (1975), the discrimination index of a reagent is accepted if it yields a value greater than 0.2 or 0.3. The IDC scale according to Backhoff, Larrazolo and Rosas (2000) is: bad (IDC <0.20), regular (0.20 <IDC <0.30), good (0.30 <IDC <0.40) and excellent (IDC> 0.40).

Final thoughts

A remedial course was designed for the subject of Differential Calculus called "Functions and Derivatives" to support students who are taking the Integral Calculus UA, with the aim that each of the students who take it acquire the mathematical skills of Differential Calculus that allows you to successfully complete your time at the Comprehensive Calculus UA.

A team of judges evaluated whether the contents of the reagents inquired about the topics of the Differential Calculus UA proposed, if the reagents are indicators of what it is intended to measure, the judgments of the professionals were favorable in relation to the diagnostic possibilities of each one of the polls.

To calculate the reliability, two methods were used, KR-20 and split halves, the results are consistent between the first version and the last one, so the instrument is highly reliable and its use can be considered to be applied on a large scale.

The importance of this remedial course lies in the help it provides to the student in the possible learning lags of Differential Calculus that have always existed and that have increased after the COVID19 pandemic.

References

Agudelo, M. (2009). *Importancia del diseño instruccional en ambientes virtuales de aprendizaje.* En J. Sánchez (Ed.): Nuevas Ideas en Informática Educativa, 5, 118 – 127, Santiago de Chile.

Alsina, Á. y Coronata, C. (2014). Los procesos matemáticos en las prácticas docentes: diseño, construcción y validación de un instrumento de evaluación. *Educación Matemática En La Infancia*, *3*(2), 23–36.

Avitia, P., Candolfi, N., Arellano, E. y Uriarte, I. (noviembre de 2014). Implementación de cursos de matemáticas para estudiantes de Ingeniería en modalidad semipresencial: la experiencia de CITEC Valle de las Palmas. Congreso Iberoamericano de Ciencia, Tecnología, Innovación y Educación. Buenos Aires, Argentina.

Backhoff, E., Larrazolo, N. y Rosas, M. (2000). Nivel de dificultad y poder de discriminación del examen de habilidades y conocimientos básicos (EXHCOBA). *Revista Electrónica de Investigación Educativa*, *2*(1), 1-19.

Barrazas, A. (2007). La consulta a expertos como estrategia para la recolección de evidencias de validez basadas en contenido. *Investigación Educativa Duranguense, 7,* 5-13.

Betegón, L., Fossas, M., Martínez, E. y Ramos, M. (2012). Entornos virtuales como apoyo a la docencia universitaria presencial: utilidad de Moodle. *Anuario Jurídico y Económico Escurialense, XLIII,* 273-302.

Brioli, C. y Garcial, I. (2011). Referente teórico y metodológico para el diseño instruccional de entornos virtuales de enseñanza y aprendizaje (EVEA). *Docencia universitaria, XII* (2), 71-99.

Bruner, J. S. (1969). *Hacia una teoría de la instrucción*. México: Uthea.

Chiappe, A. (2008). Diseño instruccional: oficio, fase y proceso. *Educación y Educadores, 11*(2), 229-239.

Coll, C. y Monereo, C. (2008). Psicología de la educación virtual. Madrid: Ediciones Morata, S. L.

ISSN-On line: 2531-2979

Cisneros, E., Jorquera, M. y Aguilar, A. (2012). Validación de instrumentos de evaluación docente en el contexto de una universidad española. *Voces y Silencios: Revista Latinoamericana de Educación, 3*(1), 41-55.

Contreras, L. A. (1998). *Metodología para desarrollar y validar un examen de español, de referencia criterial y referencia normativa orientado por el curriculum, para la educación primaria en México,* en Tercer Foro Nacional de Evaluación Educativa. Memorias. Veracruz: CENEVAL.

Contreras, L. A. (2000). *Desarrollo y pilotaje de un examen de español para la educación primaria en Baja California.* Tesis. Recuperado de: http://eduweb.ens.uabc.mx/egresados/index.html (Consultado el 16-09-2005).

Contreras, L., Backhoff, E. y Larrazolo, N. (2004). *Educación, aprendizaje y cognición. Teoría en la práctica.* México: Manual moderno.

Córica, J. L., Portalupi, C., Hernández, M. L. y Bruno, A. (2010). *Fundamentos de diseño de materiales para educación a distancia.* 1ª edición, Editorial Virtual Argentina, Mendoza, Argentina.

Crocker, L. y Algina, J. (1986). *Introduction to Classical and Modern Test Theory.* Florida: Holt, Rinehart and Winston.

Dillenbourg, P., Schneider, D. y Synteta, P. (2002). Virtual Learning Environments. Proccedings of the 3rd Hellenic Conference “Information & Communication Technologies in Education”, 3-18.

Escontrela, R. (2003). Bases para reconstruir el diseño instruccional en los sistemas de educación a distancia. *Revista Docencia Universitaria, 1* (4), 25-48.

García, L. (2017). Educación a distancia y virtual: calidad, disrupción, aprendizajes adaptativo y móvil. *RIED. Revista Iberoamericana de Educación a Distancia, 20*(2), 9-25. doi: http://dx.doi.org/10.5944/ried.20.2.18737

Gil, M. C. (2004). Modelo de diseño instruccional para programas educativos a distancia. *Perfiles educativos, 26* (104), 93-114.

Guàrdia, L. y Sangrà, A. (2005). Diseño instruccional y objetos de aprendizaje; hacia un modelo para el diseño de actividades de evaluación del aprendizaje on-line. *RED. Revista de Educación a Distancia,* 4, 1-14. Recuperado de: https://www.um.es/ead/red/M4/guardia17.pdf

Gutiérrez, M.A. (1997). *Educación multimedia y nuevas tecnologías*. Madrid: Ediciones de la Torre.

López, R. (2005). Deficiencias en matemáticas que afectan el aprendizaje del cálculo diferencial en estudiantes de Ingeniería de una universidad privada (Tesis de Maestría). Universidad Industrial de Santander, Bucaramanga.

López, A. E., Ledesma, R. y Escalera, S. (2009). Ambientes Virtuales de Aprendizaje. Instituto Técnico Profesional. México, 2009. Recuperado de: http://investigacion.ilce.edu.mx/panel_control/doc/Rayon_Parra.pdf

Nitko, A. J. (1994). A Model for Developing Curriculum-Driven Criterion-Referenced and Norm-Referenced National Examinations for Certification and Selection of Students. Conferencia Internacional sobre Evaluación y Medición Educativas, de la Asociación para el Estudio de la Evaluación Educativa (ASSESA).

Osuna, F. y Abarca, F. (2013). Los nuevos roles en entornos educativos extendidos en red. La experiencia de diseño de un entorno virtual de aprendizaje en educación superior. *Revista de Docencia Universitaria*, *11*(2).

Pineda, G. (2008). Análisis de los factores que inciden en la reprobación en los alumnos de la carrera de Ingneiero Bioquímico de la Escuela Nacional de Ciencias Biológicas del Instituto Politécnico. Tesis de Maestría, Instituto Politécnico Nacional, enero 2008. Recuperado de: https://tesis.ipn.mx/jspui/bitstream/123456789/4240/1/ANALISISFACTORES.pdf

Popham, J. (1990). *Modern educational Measurement: a practitioner’s perspective*. Boston: Prentice Hall.

Riego, M. A. (2013). Factores académicos que explican la reprobación en cálculo diferencial. *Conciencia Tecnológica*, 46, julio-diciembre, 29-35. Recuperado de: https://www.redalyc.org/pdf/944/94429298006.pdf

Ruiz, E. F., Carmona, E. A. y Montiel, A. S. (2016). Importancia del cálculo en el desarrollo académico del ingeniero. *Pistas Educativas,* 120, noviembre de 2016, 402-420.

Umaña, A. C. (2009). Consideraciones pedagógicas para el diseño instruccional constructivista. *Innovaciones Educativas, 11*(16), 1-18.

Vasquez, D. (2020). Ventajas, desventajas y ocho recomendaciones para la educación médica virtual en tiempos de COVID-19. Rev CES Medicina, Especial COVID-19, 14-27.

Zúñiga, L. (2007). El cálculo en carreras de ingeniería: un estudio cognitivo. *Revista Latinoamericana de Investigación en Matemática Educativa, 10*(1), 145-175.

Level of competence on the concept of basis of vector space using SOLO taxonomy

Nivel de competencia del concepto de base de un espacio vectorial usando la taxonomía SOLO

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Abstract

The purpose of this research paper is to determinate the level of competence on the concept of basis of a vector space on college level students who finished the Linear Algebra course, providing complementary information to the various studies from a different perspective through the SOLO taxonomy (Structure of the Observed Learning Outcome). An instrument was designed to address the concept of basis from different perspectives and difficulty degrees; it was applied through individual video-recorded interviews. Their answers were analyzed, and it was found that they average level 3 (multistructural) of the taxonomy: the students know the basis definition from an algorithmic or methodological perspective, and they can reproduce some procedures, but they are unable to understand the basis concept.

Vector space, Basis, SOLO taxonomy

Resumen

El propósito de esta investigación es determinar el nivel de competencia sobre el concepto de base de un espacio vectorial en estudiantes de nivel superior que concluyeron el curso de Álgebra Lineal, proporcionando información complementaria a diversos estudios desde una perspectiva diferente a través de la taxonomía SOLO (Estructura del Resultado Observado del Aprendizaje por sus siglas en inglés). Se diseñó un instrumento abordando el concepto de base desde diferentes perspectivas y grados de dificultad; aplicando entrevistas individuales videograbadas. Analizando sus respuestas, se encontró que en promedio alcanzan el nivel 3 (multiestructural) de la taxonomía: los estudiantes conocen la definición de base desde una perspectiva algorítmica o metodológica, pueden reproducir algunos procedimientos, pero son incapaces de comprender el concepto de base.

Espacio vectorial, Base, taxonomía SOLO

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Introduction

In the Linear Algebra course taught in the engineering careers of the Tecnológico Nacional de México (TecNM), it has been detected that student have greater difficulty in understanding and assimilating the concepts related to the subject of vector spaces. There are multiple investigations that address this problem and they refer to the abstract nature and complexity of these concepts (Guzman and Zambrano 2015; Vera and Miranda 2014; Parraguez and Vera-Soria 2020).

The base concept constitutes a fundamental element of the structure of a vector space and is fundamentally related to other concepts (Ku, Trigueros and Oktaç, 2008). For this reason, it is useful to evaluate the assimilation of this concept to obtain a sample of the understanding that students have of the subject of vector spaces.

The Linear Algebra course is found within several university-level study programs (TecNM), especially in those engineering programs where the concepts and methods are retaken for their application in subsequent subjects.

This study attempts to answer the following research question: What level of competence do students have about the concept of the basis of a vector space at the end of the Linear Algebra course?

To answer this question, an instrument was designed that measures the level of competence of the basic concept, using the SOLO taxonomy whose levels show the degree of understanding that students have in a given topic, the instrument is found in Annex 1. The instrument was applied through a video-recorded interview and the responses of each student were analyzed.

Background

In recent decades, interest has arisen in the study of Linear Algebra, specifically in the understanding of vector spaces, Dubinsky (2001) mentions the problems faced by students experiencing "confusion and disorientation" when analyzing subspace topics, generator set, linear independence, etc.

Some investigations related to the concept of base are those of Ku (2008) which is oriented in the study of the understanding of the concept of base of a vector space. Oktac (2010) delves into how university students learn linear algebra considering the construction of the concept of vector space, linear transformations and base. Parraguez (2013) explains the role of the body in the construction of the vector space concept. Vera (2018) makes an inquiry about the process of its construction, through the assessment of the different ways of perceiving the basic meaning. The aforementioned investigations have been carried out from the APOE theory (Action, Process, Object and Scheme) developed by Dubinsky.

Martín, *et al.*, (2014) reviewed several articles that show interest in the teaching-learning topics of Linear Algebra specifically where the topics of Vector Spaces are involved. Madrid, Cribeiro and Sánchez (2016), after investigating and carrying out an analysis of the difficulties in learning the subjects of vector spaces, developed worksheets that led the student to develop the necessary skills on the concept of vector space.

Theoretical framework

Concepts

There are some basic knowledge on which most of the concepts related to vector spaces are based, the most relevant are those of Base, Dependency and Linear Independence and generated space that, according to Grossman and Flores (2012) are defined as follows:

Base:

A finite set of vectors {v1, v2, …, vn} is a basis for a vector space V if

i) {v1, v2, …, vn} is linearly independent.

ii) {v1, v2, …, vn} generates V

Linear dependence and independence:

Let v1, v2, …, vn, n vectors in a vector space V. Then the vectors are said to be linearly dependent if there are n scalars c1, c2, …, cn not all zero such that:

$$c_1v_1 + c_2v_2 + \ldots + c_nv_n = 0$$

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If the vectors are not linearly dependent, they are said to be linearly independent.

Generated space

Let v1, v2, …, vk be vectors of a vector space V. The space generated by {v1, v2, …, vk} is the set of linear combinations v1, v2, …, vk. That is, gen {v1, v2, …, vn} = {v: v = a1v1 + a2v2 +… + akvk}

Where a1, a2, ..., ak are arbitrary scalars.

SOLO taxonomy

The structure of the observed learning outcome, known as the SOLO taxonomy (Structure of the Observed Learning Outcome): "It provides a systematic way of describing how the complexity of the student's learning increases as he masters academic tasks" (Biggs, 2006).

The SOLO taxonomy has the following levels:

1.- Prestructural: they do not give proof of relevant learning. The student does not understand the topic.

2.- Unistructural: it only fulfills a part of the task, they stay in the terminology, they are well oriented, but only in one aspect. At this level the student identifies or performs a simple procedure.

3.- Multistructural: performs a series of tasks, which can be enumerate, describe, make a list, combine and are capable of developing algorithms.

4.- Rational: not only do they have a set of data and details, they address a point and give meaning to the topic, it has a relevant meaning and leads to understanding. The student compares, explains causes, analyzes, relates and applies knowledge

5.- Extended abstract: it is conceptualized at a higher level of abstraction and applied to new, broader fields. The student theorizes, generalizes, formulates hypotheses and reflects.

This theory allows evaluating learning outcomes, giving information on the level the student is at and giving the opportunity to search for specific strategies to lead the student to reach a new level of knowledge.

Methodology

The participants in the study were 18 students from two different groups of the second semester of the Computer Systems Engineering career who finished the course of Linear Algebra at the TecNM, Chihuahua II campus, who were invited randomly.

An individual interview was conducted through which the items were provided one by one, which were designed as follows:

- In the first five questions they were asked to determine if a set of vectors in R2 or R3 is a basis for the indicated vector space.

- In the following three questions it was suggested to determine if the set of vectors is a basis for the vector space indicated, using second-degree polynomials and 2x2 matrices.

- In the last three questions, they were asked to determine a base for the entire set of points of a plane in three dimensions, of a line, also in three dimensions, and for the set of 3x3 diagonal matrices.

The complete reagents can be seen in Annex 1.

In this part, the strategy consisted in that, if the professor who carried out the interview detected arithmetic errors in the students' procedures, he guided them to correct their operations in order to reach a conclusion. The interviewer questioned the student about his conclusions in order to inquire about the level of understanding of the basic concept.
The interview was videotaped to later establish the analysis of the responses provided by the students, which they reached through operations, or verbally expressing their justification regarding their conclusions.

Therefore, the study is descriptive-interpretive, since the recordings of the interviews were analyzed to determine the level of competence that each of the participants had.

Results

Students were located at each level as shown below.

Level 1. Prestructural

No student was found at this level, as all showed at least a basic notion of the basic concept.

Level 2. Unistructural

Three of the eighteen students were at this level, they mastered a single task and those items that did not correspond to the latter, which they could not solve, were left unanswered. According to the procedures shown, these students were able to obtain the determinant, or, form a matrix and match to zeros to determine linear independence through definition, although some used row reduction to determine whether it corresponded to a generator set.

Thus, for example, one of the students, at the unistructural level, proposed a procedure to verify if the set of vectors generated the vector space in all the exercises, without mentioning linear independence. However, there were cases in which, even with the procedure, they did not conclude correctly, this is the case of the reagent presented below:

Determine if the given set of vectors is a basis for the indicated vector space:

$$\left\{\begin{bmatrix}-3\\1\\2\end{bmatrix},\begin{bmatrix}4\\0\\-1\end{bmatrix}\right\} \text{In } R^3 \quad (1)$$

In the following figure you can see the procedure performed by the student.

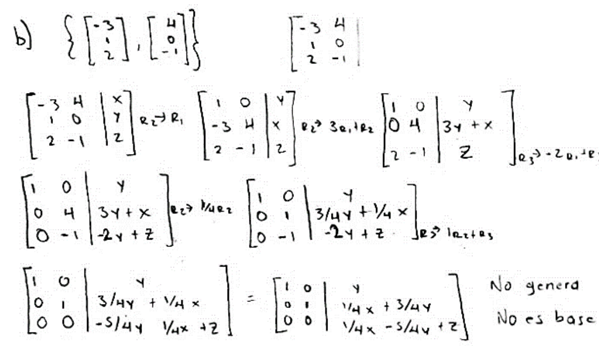

Figure 1 Photograph of the procedure of exercise I.b carried out by a student who reached level 2

Even when the student carried out the procedure that is used daily to determine the space generated by vectors, he could not interpret it, he concluded: “It is not a base since I have zero equal to something of x, y, z. It is not consistent, a set of zeros cannot be equal to x, y, z".

Level 3. Multistructural

Eight of the eighteen students performed various procedural tasks, applied the definition using row reduction, and concluded whether the vectors in R2 or R3 were linearly independent. They also carried out procedures to determine if this was a generator set and to conclude, also, if it corresponded to a basis, or not, of a vector space. They were not able to extrapolate the concepts of base, linear independence, and generating set to vector spaces composed of polynomials or matrices. Therefore, they were placed at level 3, because they performed algorithmic procedures without achieving a broader understanding of the underlying concept, as exemplified below.

One of the students who was able to successfully solve the questions, in which he wondered if a certain number of vectors were the basis of R2 or R3, had problems to raise those questions of matrices or polynomials:

Determine if the given set of vectors is a basis for the indicated vector space.

$$\left\{\begin{bmatrix}3 & -2\\0 & 0\end{bmatrix},\begin{bmatrix}2 & 0\\-1 & 0\end{bmatrix}\right\} \text{ for } M_{22} \quad (2)$$

In the following figure you can see the procedure of one of the students.

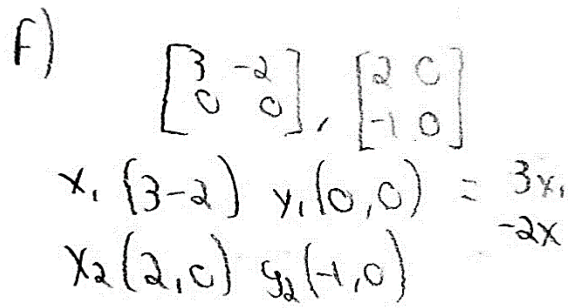

Figure 2 Photograph of the procedure of exercise I.f carried out by a student who reached level 3

The use of elements x and y that belong to the vector space R2 is appreciated, without establishing a relationship of the concepts of linear independence or space generated with the given matrices.

Level 4. Rational

Five of eighteen students were at level 4, in which they performed analysis through knowledge of the theorems or performed mathematical procedures justifying each of their operations to conclude correctly. The latter mastered the operations, with which they managed to determine the linear independence either by the definition or by the theorem, as well as the generator set, in addition, they easily determined if the vectors, polynomials or matrices shown are the basis of the space vector. They were able to solve some of the questions in which they were asked about a basis for a vector space without being certain about their answer, showing little understanding of the concept of dimension.

In the case of a student who was able to answer the questions satisfactorily, it was necessary to determine if the set of vectors is the basis of the vector space, he showed difficulties in proposing a basis for a vector space, as shown in the following example:

Determine a basis for the set of vectors in the plane 3x - 2y + z = 0 in R^3.

The student proposed as a basis the vectors that can be seen in the following figure.

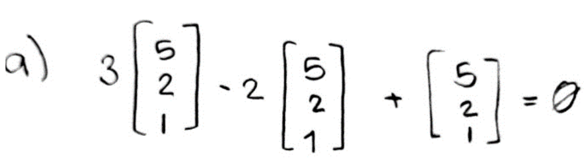

Figure 3 Photograph of the procedure of exercise II.a carried out by a student who reached level 4

He answered verbally "It comes to my mind to give values to x, y, z (pointing to the elements of the vector) so that it gives zero"

As can be seen, the student substituted a random vector in x, y, z, since they should be components of the vector and not vectors.

Level 5. Broad Abstract

Two of the eighteen students were at this level, they showed mastery of row operations to determine linear independence and the generator set, as well as the use of theorems to conclude whether it is base or not, solving those that include polynomial and matrices. In the items in which they had to propose a basis for a given vector space, they were able to analyze and determine the dimension, which corresponds to the number of vectors to be used. Thus demonstrating the domain and understanding of the concept of base of a vector space.

One of the students, in this last level, when proposing the reagent, explained the following:

Determine a basis for the set of 3 X 3 diagonal matrices.

Established the following dialogue with the interviewer

Student: The set of diagonal matrices?

Interviewer: What are the diagonal matrices?

Student: those with zeros above and below (pointing to a diagonal).

Interviewer: What would be a basis for those matrices?

Student: For all of them?

Interviewer: There they specify which ones, of 3 X 3

Student: Yes, it would be 3 linearly independent matrices.

The following figure 4 shows the student's response.

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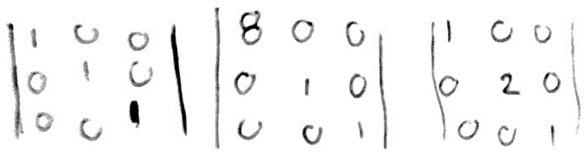

Figure 4 Photograph of the procedure of exercise II.b carried out by a student who reached level 5

He easily intuited that he needed three linearly independent diagonal matrices, applying the concept of base and dimension to a type of problem that is not seen in class.

Conclusion

The results obtained showed that the average level of competence presented by the students is multistructural in nature, arithmetically averaging 3.33, which means that they know the basic definition from an algorithmic or methodological perspective, managing to reproduce some procedures without having an understanding of the concepts related to the basis of a vector space.

Knowing that the base concept of a vector space is abstract, it is convenient for students to develop activities that help better understanding, as proposed by Madrid, Cribero and Sanchez (2016).

Annex 1 Instrument

I.- Determine if the given set of vectors is a basis for the indicated vector space.

$a\left\{\begin{bmatrix}1\\2\end{bmatrix},\begin{bmatrix}-1\\4\end{bmatrix},\begin{bmatrix}3\\1\end{bmatrix}\right\} en R^2$

$b\left\{\begin{bmatrix}-3\\1\\2\end{bmatrix},\begin{bmatrix}4\\0\\-1\end{bmatrix}\right\} en R^2$

$c\left\{\begin{bmatrix}3\\-1\\2\end{bmatrix},\begin{bmatrix}4\\1\\5\end{bmatrix},\begin{bmatrix}-2\\-1\\-3\end{bmatrix}\right\} en R^3$

$d\left\{\begin{bmatrix}-1\\0\\1\end{bmatrix},\begin{bmatrix}0\\-1\\1\end{bmatrix},\begin{bmatrix}1\\-1\\0\end{bmatrix}\right\} en R^3$

$e\left\{\begin{bmatrix}1\\1\\0\end{bmatrix},\begin{bmatrix}0\\1\\1\end{bmatrix}\right\} en R^2$

$f\left\{\begin{bmatrix}3 & -2\\0 & 0\end{bmatrix},\begin{bmatrix}2 & 0\\-1 & 0\end{bmatrix}\right\} para M_{22}$

$g\{2t^2-t, t+4, t^2+1\} para P_2$

$h\{x^2-4, 3x^2, 5\} para P_2$

II.- Determine a basis for:

a) In R^3 for the set of vectors in the plane 3x-2y + z = 0

b) In R^3 for the set of vectors on the line x = 4t, y = -2t, z = -t

c) In M_{33} for the set of diagonal matrices.

References

Grossman, S. I., & Flores, J. J. (2012). *Álgebra Lineal* (7th ed.). Mc Graw Hill.

Guzman, J., & Zambrano, J. (2015). Base de un espacio vectorial de Rn y tecnología. *XIV Conferencia Interamericana de Educación Matemática*.

Parraguez, M., & Vera-Soria, G. (2020). Los modos de pensamiento sintético y analítico en la comprensión de base en el espacio vectorial R2: Un estudio de casos en un contexto universitario. *Revista Paradigma*, *41*, 600–365.

Vera, M. G., & Miranda, E. (2014). El aprendizaje de espacios vectoriales en ambientes computacionales. *Acta Latinoamericana de Matemática Educativa*, *27*, 2195–2203.

Martín, Á., Pérez, O., Blanco, R., & Casas, L. (2014). Los espacios vectoriales, como estructuras algebraicas, en el proceso de enseñanza aprendizaje del álgebra lineal: Una propuesta de investigación. *Acta Latinoamericana de Matemática Educativa*, *27*, 1073–1082. http://funes.uniandes.edu.co/5666/1/MartinLosespaciosALME2014.pdf

Vera, M. G., Parraguez, M., Paredes, I., & Garcia, D. (2018). Los modos de pensamiento en el proceso de comprensión del concepto de base del espacio vectorial R2 y R3. *Acta Latinoamericana de Matemática Educativa*, *31*(2), 1217–1225.

Madrid, H., Cribeiro, J. M., & Sánchez, M. L. (2016). Espacios vectoriales desde la realidad a la abstracción. *El Cálculo y Su Enseñanza*, *7*, 1–8.

June 2021, Vol.5 No.8 10-16

Dubinsky, E. (2001). Some Thoughts on a first course in Linear Algebra at the college level. *MAA NOTES*, *620*, 85–106.

Kú, D., Trigueros, M., & Oktaç, A. (2008). Comprensión del concepto de base de un espacio vectorial desde el punto de vista de la teoría APOE. *Educación Matemática*, *20*(2), 65–89. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1665-58262008000200004

Biggs, J. (2006). *Calidad Del Aprendizaje Universitaria* (2nd ed.). Narcea, SA de ediciones.

Parraguez González, M. (2013). El rol del cuerpo en la construcción del concepto Espacio Vectorial. *Educación Matemática*, *25*(1), 133–154.

Oktaç, A., & Trigueros, M. (2010). ¿Cómo se aprenden los conceptos de álgebra lineal? *Revista Latinoamericana de Investigación En Matemática Educativa, RELIME*, *13*(4), 373–385.

Method of typification of the growth curve of the Andean guinea pig with the logistic model

Método de tipificación de la curva de crecimiento del cuye raza Andina con el modelo logístico

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Abstract

For the characterization of the growth curve first weight was measured from birth to slaughter 50 Cuyes data needed in the formulates of the logistic model. Microsoft Excel is used to plot the trend curve and return coefficient of determination given with each movement of factors A, K and B; the accuracy of the model, then the model with factors Curve Expert 1.6 software version is confirmed and finally a One Way ANOVA statistical test is performed to verify that the models are statistically no difference. A growth curve for Andean guinea pigs breed, adapted to the study region with a prescribed diet is typified; no statistical difference between the logistic model from the actual data found. This model can predict weight gain reliably, over the life of production cuye.

Biomodeling, Pattern, Animal production, Birth, Weaning, Sacrifice, Minitab, Excel, Curve expert

Resumen

Para la tipificación de la curva de crecimiento primero se midió el peso desde el nacimiento hasta el sacrificio de 50 Cuyes, datos necesarios en la fórmula del modelo logístico. Se utiliza Microsoft Excel para graficar la curva de tendencia y restablecer el coeficiente de determinación que dará con cada movimiento de los factores A, K y B; la exactitud del modelo, posteriormente se confirma los factores del modelo con un software Curve Expert versión 1.6 y por último se realiza una prueba estadística de ANOVA Unidireccional, para verificar que los modelos sean estadísticamente sin diferencias. Se tipifico una curva de crecimiento para cuyes raza andina, adaptada a la región de estudio con una dieta preestablecida; no se encontró diferencias estadísticas entre el modelo logístico respecto a los datos reales. Este modelo puede predecir la ganancia de peso en forma confiable, a lo largo de la vida del cuye en producción.

Biomodelación, Modelo, Producción animal, Nacimiento, Destete, Sacrificio, Minitab, Excel, Curve expert

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Introduction

Animal growth can be replicated through the use of mathematical functions, which predict the evolution of live weight over time, allowing evaluations to be made of the level of production in livestock farms, and the productivity of a specific breed for a given area can be classified in a simple way (Parks, 1982).

The various sigmoidal mathematical models model both population and individual growth (Noguera et al., 2008), the logistic model and the Von Bertalanffy model, among others, belong to the family of equations that can be broken down in the function of

Richards (Richards, 1959), and are frequently used for the adjustment of individual growth curves in the biological field (Garcia, 2005).

The Gompertz, Logistic, Richards, Bertalanffy and Brody models are the most frequently used growth functions to describe the growth of animal plants and organs. These models present three parameters with biological interpretation and one defined as a mathematical constant. Parameter "A" corresponds to the asymptotic weight or adult weight, representing the estimate of the weight at maturity. The parameter "K" corresponds to the maturity index or the estimate of maturity precocity (Nobre et al., 1987). The higher the value of this parameter, the earlier the animal and vice versa (Brown et al., 1976).

Formula logistic model (Verhulst, 1838):

$$y = \frac{A}{(1+K*e^{(-B*x)})}$$

The formula of the logistic model considers these factors with the following denomination: Parameter "A" Corresponds to the asymptotic weight or adult weight, represents the estimate of weight at maturity. Parameter "K" corresponds to the maturity index or the estimate of maturity precocity. The higher the value of this parameter, the earlier the animal is and vice versa. The parameter "B" is called integration parameter and has no biological significance.

The parameter "x" corresponds to the independent variable Time expressed in x unit of time (days, weeks, months, etc.). The parameter "y" is the weight when "x" tends to a finite value.

The existence of varieties of guinea pig breeds focused on different productive factors such as rapid weight gain or greater number of offspring per parturition, among others, together with the growing international demand for guinea pig meat, amply justifies the typification of its growth equation, of a logistic type, as well as the prior determination of the productive factors of the model on the Andean Guinea pig (Solari, 2010).

In work with guinea pigs, the average number of live and weaned offspring per parturition was 3.46±1.4 and 2.51±1.29, respectively. Birth weight and weaning weight averaged 86.7±21.6 g and 167.9±24.6 g, respectively. The averages found for live weight, carcass weight and carcass yield for 5-month-old non-fasting males were 955±106 g, 420±54 g and 43.98±3 % (Xicohtencatl et al., 2013).

In contrast, Chauca (1997) found birth and weaning weights of 121±2.4 g and 310±6.53 g, respectively. Apráez-Guerrero et al. (2009) reported average birth and weaning weights of 130.28±12.73 g and 259.69±14.46.

Material and methods

The guinea pigs were measured at the farm of the Escuela Secundaria Técnica No. 2 SEPEN, located in the Municipality of Xalisco, Nayarit, Mexico. The farm has 100 Andean breed (between first and 4th parturition) Andean breed guinea pigs with continuous postpartum mating in jal block stalls and cement floor; fed free access with pelleted feed (with 18 % crude protein, with Tanzanian forage with a crude protein percentage of 4.64 % grown on the farm, orange waste obtained from businesses that sell juices from the neighboring market and water.

For the typification of the growth curve, the birth weight of 50 guinea pigs was measured first, and in the following days until slaughter, as shown in Table 1.

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1. The data were normalized and averaged to reduce the experimental error.

Edad (Dias)	Peso (grs.)
1	88.27
8	143.08
11	169.97
16	210.77
23	250.77
30	285.38
60	546.80
91	805
150	950.00

Table 1 Andean guinea pig weights per day

Determining the initial parameters of the logistic model A, K and B, the parameter K, which in this case K = 6.19 and the natural logarithm of the slope will give the initial value of the constant of integration B, which in this case B= 1.82.

In the case of the constant of integration we will always use very small values (fractions less than 1) and they can even be negative.

These values will be used in the formula of the logistic model in a fixed way varying only the value of "x" (days) to determine the modeled data and subsequently determine its coefficient of determination and standard error. If the model is not adequate, we will adjust the factors again and recalculate the accuracy values and so on.

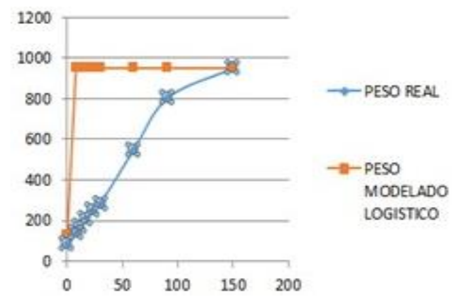
To facilitate this work, Microsoft Excel is used to plot the trend curve and restore the coefficient of determination that will give with each movement of the factors A, K and B; the accuracy of the model, then the factors of the model are confirmed with a software Curve Expert version 1.6 and finally a statistical test of One-way ANOVA is performed, to verify that the models are statistically without differences.

Plots showing the projection of the modeled values with the initially calculated factors.

Factores	
A	950
K	6.19
B	1.82

EDAD (días)	PESO REAL (Gr)	PESO MODELADO LOGISTICO (Gr.)
0	88.27	132.13
8	143.08	950.00
11	169.97	950.00
16	210.77	950.00
23	250.77	950.00
30	285.38	950.00
60	546.80	950.00
91	805	950.00
150	950.00	950.00

Table 2 Modeled vs. Actual Data



Graphic 1 Initial vs Actual logistic model

An improvement of the model can be observed, which already has an accuracy of 60% over the real data model.

In this first approximation a very inaccurate model can be determined and we must make adjustments to the slope and constant of integration, the first thing would be to adjust the constant and integration to a value fraction less than one.

Factores	
A	950
K	6.19
B	0.08

EDAD	PESO REAL	PESO MODELADO LOGISTICO
0	88.27	132.13
8	143.08	222.80
11	169.97	266.29
16	210.77	349.13
23	250.77	479.05
30	285.38	608.37
60	546.80	903.95
91	805	945.96
150	950.00	949.96

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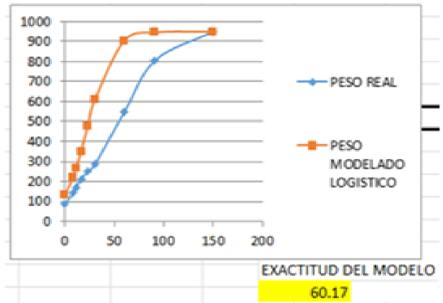
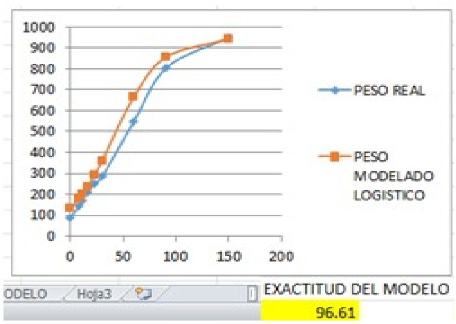
June 2021 Vol.5 No.8 17-22



By simply adjusting the integration factor, a good fit is obtained, now that same factor is lowered to 0.0445.

Factores	
A	950
K	6.19
B	0.0445

EDAD	PESO REAL	PESO MOD LOGISTICO
0	88.27	132.13
8	143.08	178.04
11	169.97	198.16
16	210.77	235.31
23	250.77	294.64
30	285.38	361.36
60	546.80	664.95
91	805	857.48
150	950.00	942.64

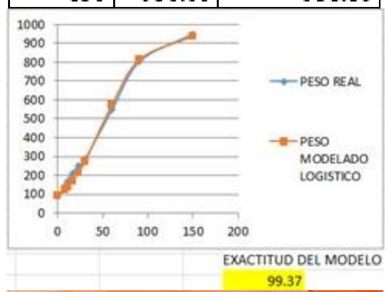


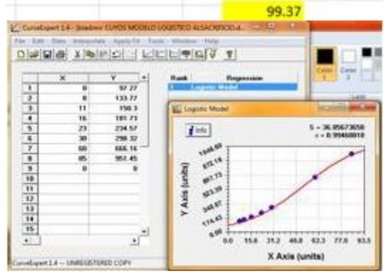
And as a last step, the factor K or earliness of growth (slope) is adjusted from K=6.19 to K =9.45, observe the adjustment that originates and its corresponding coefficient of determination that yields.

Factores	
A	950
K	9.45
B	0.0445

With this approximation, the model is adjusted and these model factors are checked with the curve expert 1.4 software, obtaining the following results:

EDAD	PESO REAL	PESO MODELADO LOGISTICO
0	88.27	90.91
8	143.08	124.68
11	169.97	139.87
16	210.77	168.54
23	250.77	216.12
30	285.38	272.45
60	546.80	574.21
91	805	815.64
150	950.00	938.80





A correlation coefficient of 0.9946 and a standard error of 36.85 are obtained, indicating that the calculations are valid and with an excellent level of accuracy.

We now proceed to apply an analysis of variance between groups of data: real and model data, to determine if there are differences or if they are statistically equal with a percentage of alpha at 5%; this one-way ANOVA test is performed with the Minitab 16 statistical package, which yields the following results: (P>0.5) finding no differences between the two models.

Minitab run results

One-way ANOVA: ACTUAL WEIGHT, LOGISTICS MODELED WEIGHT

Source GL SC MC F P
Factor 1 223 223 0.00 0.962
Error 14 1301056 92933
Total 15 1301279

S= 304.8 R-cuad.= 0.02%
R-cuad.(adjusted) = 0.00%

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Level	N	Media	Dsv.Est.
ACTUAL WEIGHT	8	346.7	303.7
WEIGHT M LOG.	8	339.2	306.0

Individual 95% CIs for the mean based on pooled standard deviation.

Grouping information using Tukey's method:

	N	Media	Grouping
PESO REAL	8	346.7	A
PESO M LOG.	8	339.2	A

Means that do not share a letter are significantly different.

Clustering data using Tukey's method

	N	Media	Grouping
PESO REAL	8	346.7	A
PESO M LOG.	8	339.2	A

Means that do not share a letter are significantly different.

Results

An average birth weight of Andean breed guinea pigs was 88.27 g and at 150 days of age 950 g. These data are in agreement with studies that report an average birth weight of 86.7±21.6 g and a live weight for 5-month-old non-fasting males of 955±106 g (Xicohtencatl et al., 2013). Improved guinea pigs reach at 4 months of age, the weight between 1.2 to 1.5 kg can exceed these values with a higher degree of genetic improvement (Solari, 2010).

A growth curve was typified for Andean breed guinea pigs, adapted to the study region with a pre-established diet; no statistical differences were found between the logistic model and the real data. This model can reliably predict weight gain throughout the life of the guinea pig in production, the model formula would be:

Typified logistic model formula:

$$y = \frac{950}{(1+9.45*e^{(-0.0445*x)})}$$

Where the independent variable "x" will be the guinea pig days of life, the dependent variable "y" will capture the guinea pig weight for "x" days of life, this model is 99.37 accurate with respect to the real growth pattern behavior. Validated with statistical test without finding significant differences with an alpha = 0.05 obtaining a p-value = 0.962.

This model could answer several questions such as:

What is the guinea pig's birth weight?

What is the weaning weight?

What is the guinea pig's weight at 60 days?

After how many days will your weight be 500 grams?

What is the guinea pig's weight gain between 30 and 60 days? Etc.

Conclusion

A growth curve for Andean breed guinea pigs, adapted to the study region with a pre-established diet, was typified; no statistical differences were found between the logistic model and the real data. This model can reliably predict weight gain throughout the life of the guinea pig in production.

References

APRÁEZ-GUERRERO JE, FERNÁNDEZ-PÁRMO L, HERNÁNDEZ-GONZÁLEZ A. Evaluación del comportamiento reproductivo de cuyes (Cavia porcellus) alojados en jaulas y pozas. Vet. Zootec. 2009; 3(1): 25-31.

BROWN JE, FITZHUGH JR HA, CARTWRIGHT TC. A comparison of nonlinear models for describing weight age relationships in cattle. J. Anim. Sci. 1976; 42: 810-818.

CHAUCA DE ZL. Producción de cuyes (Cavia porcellus) Organización de las Naciones Unidas para la Agricultura y la Alimentación. Roma, Italia.
1997.

ISSN-On line: 2531-2979

http://www.fao.org/docrep/W6562S/W6562S00.htm

GARCÍA MC. Ajuste de una curva de crecimiento utilizando la función de Gompertz. FABICIB. Rev. de la Fac. de Bioq. y Cien. Biol. UNL. 2005; 9:121-130.

NOBRE PRC, ROSA ADN, DA SILVA LOC, EVANGELISTA SRM. Curvas de crescimento de gado Nelore ajustadas para diferentes frequências de pesagens. Pesquisa Agropecuária Brasileira. 1987; 22(10): 1027-1037.

NOGUERA RR, PEREIRA RL, SOLARTE CE. Comparación de modelos no lineales para describir curvas de crecimiento en cuyes (Cavia porcellus) desde el nacimiento hasta la edad de sacrificio. Livestock Researchfor Rural Development. 2008; 20 (79).

PARKS JA. Theory of feeding and growth of animals. Springger-Verlag. Berlin. 1982:451.

RICHARDS FJ. A flexible growth functions for empiricaluse. J. Exp. Bot. 1959; 10:290-300.

SOLARI G. Ficha Técnica de Crianza de cuyes. Soluciones Prácticas-ITDG. Lima, Perú. 2010.

VERHULST PF. Notice sur ia loi que la population pursuit dans son accroissement. Corresp Math Phys ; 1838;10:113-121.

XICOHTENCATL SP, BARRERA ZS, OROZCO OT, TORRES SSFM, MONSIVAIS IR. Parámetros productivos de cuyes (Cavia porcellus) del nacimiento al sacrificio en Nayarit, México. Abanico veterinario. 2013; 3(1): 36-43.

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June 2021 Vol.5 No.8 23-30

Educational application based on MATLAB for the analysis of transient stability of power systems

Aplicación educativa basada en MATLAB para el análisis de la estabilidad transitoria de sistemas de potencia

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Abstract

This paper presents an educational computer implementation for transient stability analysis of power systems. The transient stability is formulated by considering the One-Machine Infinite Bus model and by solving a unified way the Differential Equations System by combining the Implicit Trapezoidal Rule and Newton-Raphson method. The proposed implementation is developed by using the visual programming environment GUIDE of Matlab, and it has a friendly user interface, intuitive and very easy to handle; it is also computationally efficient and numerically stable for use in all subjects related to computer-assisted analysis of power systems, either in workshop environment or distance learning courses. The implementation avoids the integration of a numerical method for solving the OMIB model, which greatly reduces development time and obtaining results,

Educational implementation, MATLAB, Transient Stability, One-Machine Infinite Bus

Resumen

Este trabajo presenta una implementación informática educativa para el análisis de la estabilidad transitoria de los sistemas de potencia. La estabilidad transitoria se formula considerando el modelo de bus infinito de una máquina y resolviendo de forma unificada el sistema de ecuaciones diferenciales mediante la combinación de la regla trapezoidal implícita y el método de Newton-Raphson. La implementación propuesta se desarrolla utilizando el entorno de programación visual GUIDE de Matlab, y cuenta con una interfaz de usuario amigable, intuitiva y muy fácil de manejar; además es computacionalmente eficiente y numéricamente estable para su uso en todas las asignaturas relacionadas con el análisis asistido por ordenador de sistemas de potencia, ya sea en entorno de taller o en cursos a distancia. La implementación evita la integración de un método numérico para la resolución del modelo OMIB, lo que reduce en gran medida el tiempo de desarrollo y la obtención de resultados,

Implementación educativa, MATLAB, Estabilidad transitoria, Bus infinito de una máquina

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Introduction

Stability has been recognized as an important problem for the safe operation of Electric Power Systems (EPS) since 1920 (Steinmetz, 1920; AIEE-SISF, 1926). Most major outages or failures in electric power systems have illustrated the importance of studying this phenomenon (Vassell, 1991). Historically, transient instability has been the dominant stability problem in SEPs and has been a topic of attention of many of the generating companies, consumers and researchers around the world (Kundur et al, 2004). The principles of transient stability analysis are studied in the later subjects of electrical engineering and related programs, since the study of this phenomenon is complex and it is desirable that students possess well-grounded prior technical knowledge.

Electrical engineering education has been a topic of extensive debate and discussion in the political and educational arena in the last decade (Omer & Idowu, 2011). Corderoy et al. (2003) and Singh (2001) highlight in their reports the need to modernize curricular programs to respond to major changes in technology, educational policy, and industry. Most scholars of electrical engineering programs agree that one of the main approaches to reform teaching in these educational programs is through newer educational tools (Omer & Idowu, 2011), which allow students to acquire and apply knowledge in solving real problems to develop in turn the competencies for handling work situations.

This characteristic in electrical engineering students is very important, since the technical personnel who design, operate and control power systems must possess vast technical knowledge, in addition to their practical thinking and problem solving skills, so people who will work in the electrical sector must acquire practical and theoretical knowledge (Güney et al, 2014). The analysis of power systems is very complex and mostly requires the implementation of computational algorithms for the solution of models, which takes considerable time to develop and obtain results.

In recent years and thanks to the rapid development of computational systems and packages, many applications and computer programs have been developed to assist in the teaching of electrical engineering programs around the world (Güney et al, 2014; Acarnley, 2005; Omer & Idowu, 2011; Levi & Nedic, 2001; Islam & Chowdhury, 2001; Shin et al, 1999; Lee et al, 2001; Overbye et al, 1995; Larsson, 2004; Vournas et al, 2004; Ayasun et al, 2006).

It is important to mention that most of these computational tools are executable and users do not have access to the source code, which translates into a disadvantage because modifications cannot be made and students are confined to the implicit solution methods of the programs.

In the above context, this paper presents the development of a computational application based on Matlab (MathWorks, 2015) to assist teachers in teaching the study of Transient Stability of SEPs.

Whose source code is provided to electrical engineering or related students so that they can perceive the operation of the tool and can integrate their own methods and models or make the modifications that they consider pertinent in the application, with the purpose that the students acquire the knowledge and the competence of analysis and application of the same. This is possible because the proposed application is very flexible and is designed to be easily extended to other power system applications or even to other applications outside electrical engineering. applications outside electrical engineering.

The Implicit Trapezoidal Rule

The formulation of the ET problem with the OMIB model is represented by a system of system, which can be solved by different numerical integration numerical integration methods, such as the Euler's method, Modified Euler's method, Runge Kutta Methods (second and fourth order) or order) or Implicit Integration Methods. In this work the RTI is used to solve the ED system because it is a very ED system because it is a very numerically numerically very stable.

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The RTI is an method of implicit integration with which the differential equations are differential equations are integrated implicitly implicitly and converted into algebraic equations algebraic equations, so it is necessary to apply a method for is necessary to apply a solution method for these equations during each equations during each time interval (Rafian et al, 1987), in the present work we use the Newton-Raphson Newton-Raphson method is used for this purpose. method is used for this purpose. To illustrate the application of this method to RTI for the solution of differential equations differential equations, the following system is considered of n DEs.

$$\frac{dY}{dt} = f(Y) \tag{1}$$

Where f(Y) is a vector of n nonlinear algebraic expressions, while Y is a vector of n system state variables.

By applying the RTI to Equation 1) we:

$$Y_t = Y_{t-\Delta t} + \frac{\Delta t}{2}\left(f(Y_t) + f(Y_{t-\Delta t})\right) \tag{2}$$

In (2) Δt is the integration step, so the subscripts t and t-Δt indicate the evaluation of f (Y) and Y at the current time and at the previous integration step, respectively. Ordering the above equation to expand the in the Taylor series around the neighborhoods of the point Yt, truncating the higher order terms and iteratively obtaining the solution in iterative form that equation, the following expression for the Newton-Raphson method results:

$$-F(Y_t)^k = \nabla F(Y_t)^k \, \Delta Y_t^k \tag{3}$$

Where ∇F(Yt) and F(Yt) are given as follows:

In (3) the superscript k indicates the iteration number and in the gradient expression c is Δt/2. The terms F(Yt)k and ∇F(Yt)k are the evaluation of Equation (2) and the gradient of that equation, respectively, both evaluated at the kth iteration. The update of Yt:

$$\nabla F(Y_t) = \begin{bmatrix} 1 + c\dfrac{df_1(Y_t)}{dy_{1t}} & c\dfrac{df_1(Y_t)}{dy_{2t}} & \cdots & c\dfrac{df_1(Y_t)}{dy_{nt}} \\ c\dfrac{df_2(Y_t)}{dy_{1t}} & 1 + c\dfrac{df_2(Y_t)}{dy_{2t}} & \cdots & c\dfrac{df_2(Y_t)}{dy_{nt}} \\ \vdots & \vdots & \ddots & \vdots \\ c\dfrac{df_n(Y_t)}{dy_{1t}} & c\dfrac{df_n(Y_t)}{dy_{2t}} & \cdots & 1 + c\dfrac{df_n(Y_t)}{dy_{nt}} \end{bmatrix}$$

$$F(Y_t) = \begin{bmatrix} y_{1t} - \dfrac{\Delta t}{2} f_1(Y_t) \\ \vdots \\ y_{nt} - \dfrac{\Delta t}{2} f_n(Y_t) \end{bmatrix} - \begin{bmatrix} y_{1(t-\Delta t)} + \dfrac{\Delta t}{2} f_1(Y_{t-\Delta t}) \\ \vdots \\ y_{n(t-\Delta t)} + \dfrac{\Delta t}{2} f_n(Y_{t-\Delta t}) \end{bmatrix}$$

k and k is performed as follows:

$$Y_t^{k+1} = Y_t^k + \Delta Y_t^k \qquad k = k + 1 \tag{4}$$

The oscillation equation

Under the occurrence of a disturbance, the magnetic axis of the generator rotor will accelerate or decelerate with respect to the synchronous speed of the stator rotational magnetic field axis, and a relative motion will start between both axes. The equation describing this relative motion is known as the oscillation equation and is given by Expression (5) (Kundur, 1994; Saadat, 2010).

$$\frac{2H}{\omega_s}\frac{d^2\delta}{dt^2} = P_{m(pu)} - P_{e(pu)} \tag{5}$$

Where H is the inertia constant in MJ/MVA, ωs represents the electrical angular velocity, δ is the power angle of the synchronous machine measured in radians, while Pm and Pe are the mechanical and electrical power in pu, respectively. When considering the classical generator model, the expression for the electrical power in 5) depends on the transfer reactance and the angle between the internal voltage of the machine and the infinite bus, and is given as follows (Saadat, 2010):

$$P_e = \frac{EV}{X_s}\sin\delta = P_{max}\sin\delta \tag{6}$$

In most disturbances, the oscillations are of such magnitude that linearization is not permissible and the nonlinear oscillation equation must be solved. The following section illustrates the numerical solution of Equation (5) as an effective method to determine the Transient Stability of power systems.

Numerical solution of the oscillation equation using RTI

The evaluation of the Transient Stability is performed with the oscillation equation, which can be expressed in terms of two first order differential equations as follows:

$$\frac{d\Delta\omega}{dt} = \frac{1}{2H}(P_m - P_{max}\sin\delta) \tag{7}$$

$$\frac{d\delta}{dt} = \omega_s \Delta\omega \tag{8}$$

In Equation (7), three values are defined for the Pmax, which correspond to the for the Pmax, which correspond to the electrical power power supplied by the generator in pre-fault, fault and post-fault in pre-fault, fault and post-fault states. The above system of differential equations is converted into a system of nonlinear algebraic equations by applying the RTI and solved iteratively with the Newton-Raphson method as shown below:

$$\begin{vmatrix} 1 & \frac{\Delta t}{4H} P_{max}\cos\delta_t \\ -\frac{\Delta t}{2}\omega_s & 1 \end{vmatrix}^k \begin{vmatrix} \Delta(\Delta\omega_t) \\ \Delta(\delta_t) \end{vmatrix}^k = \begin{vmatrix} \Delta\omega_t - \frac{\Delta t}{4H}(P_m - P_{max}\sin\delta_t) \\ \delta_t - \frac{\Delta t}{2}\omega_s\Delta\omega_t \end{vmatrix}^k - \begin{vmatrix} \Delta\omega_{t-\Delta t} - \frac{\Delta t}{4H}(P_m - P_{max}\sin\delta_{t-\Delta t}) \\ \delta_{t-\Delta t} - \frac{\Delta t}{2}\omega_s\Delta\omega_{t-\Delta t} \end{vmatrix} \tag{9}$$

The updates of the status variables are performed as follows:

$$\Delta\omega^{k+1} = \Delta\omega^k + \Delta(\Delta\omega)^k \tag{10}$$

$$\Delta\delta^{k+1} = \Delta\delta^k + \Delta(\delta)^k \tag{11}$$

$$k = k + 1 \tag{12}$$

As mentioned, in this case, RTI is being used to RTI is being used to solve the OMIB model OMIB model, however, following a similar similar methodology the student can implement his own student can implement his own numerical solution method. numerical solution method.

Practical implementation of the proposed educational application

The educational application proposed in this article was designed based on the five dimensions of knowledge: attitudes and perceptions, knowledge acquisition, deepening knowledge, meaningful use of knowledge and mental habits (Marzano et al, 1993), with the purpose of making the student easily understand the handling and root operation of the application, thus achieving a real understanding of how the tool solves the ET problem, that is, in order to teach students to process in a grandiloquent way the information.

Considering the above, the OMIB model with the combination of the RTI and the Newton-Raphson method is implemented in a computational algorithm. In order to facilitate data management and interpretation of results in such algorithm, a Matlab Graphical User Interface (GUI) is designed and developed using a visual programming environment offered by such package known as GUIDE (MathWorks, 2015). The input data for the ET simulation, Table 1, are handled through a data entry element known as edit text, while the condition or property of each input data is indicated to the user through text elements known as static text. Two types of buttons are also used, the push button and the radio button, which are buttons on which the instructions or code to be executed to solve the ET problem are programmed. For the output data, Table 2, the static text elements are selected to program on them the result of the angle and critical time calculation, while to display the graphs the axes element is selected giving the desired size to the print window.

The input data, initial conditions, graphs and results have been grouped by panels to have a better organization of the environment, as shown in Figure 1. It should be noted that the "calculate" button only has action in the results panel, which is located between the results and the input data of the right column.

In Figure 1 it is clear that the interface clearly and directly prompts the user for the input data and displays all the variables of interest when performing a TE study by means of three graphs and three boxes.

Dato	Descripción	Dato	Descripción
f	Frecuencia eléctrica (Hz)	P_{e1} P_{e2} P_{e3}	Potencia eléctrica del generador en estado de pre-falla, falla y post-falla (pu).
Δt	Paso de integración (segundos).	t_i t_f	Tiempo de inicio y final de simulación (segundos).
H	Constante de inercia (MJ/MVA).	t_{if} t_{lf}	Tiempo de inicio y liberación de la falla (segundos).
P_m	Potencia mecánica (pu).	δ_0 $\Delta\omega_0$	Condición inicial del ángulo de potencia y cambio de velocidad inicial (rad, rad/seg).

Table 1 Input data proposed educational application

Dato	Descripción	Dato	Descripción
t_c	Tiempo de liberación crítico (segundos).	δ_c δ_{max}	Ángulo de liberación crítico y máximo (radianes).

Table 2 Output data of the proposed educational application

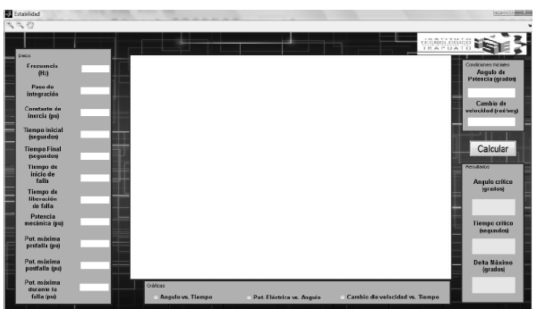

Figure 1 Environment of the proposed educational application

The graphs are controlled from the graphing panel made up of three radio button radio button selection elements, showing the first one the oscillation graph of the power angle with respect to time power angle versus time, the second the power second the behavior of the electrical power vs. the second one the behavior of the electrical power vs. its angle under fault conditions. conditions and finally the third element shows the graph of the graph of the change of synchronous speed versus time. with respect to time. These elements are located in the lower central part of the interface and the space for the and the space for the display of the graphs is the predominant predominant part of the interface. In the upper left part of the interface, zoom and manual scrolling tools have been added to facilitate the handling of the graphs.

To facilitate the handling of the graphs. In case the fault release time exceeds the critical time, a loss of synchronism warning window will be displayed, which implies that the system will lose stability.

With the introduction of the competency-based curriculum model in Mexico (Gutiérrez, 2007), educational instructions have given great importance to the development of competencies of being, knowing and knowing how to do, since it is necessary that these become permanent resources that allow students to perform adequately in the changing world of work. In this sense, the application described above tries to help to give a turn to the education in electrical engineering in a dimensional way, trying that the student understands what it does and the way in which the tool solves the problem, in order to manipulate this tool from the source code, allowing the complete understanding of the ET phenomenon of power systems, as well as the acquisition of knowledge and the application of the same in this area, with which the change in the traditional teaching is achieved and the competences for the handling of the labor situations are developed.

Use of the proposed educational application for the ET analysis of SEPs

In order to illustrate how to use the proposed application, its reliability and application is used, as well as its reliability and and usefulness, the TE of a four-unit thermoelectric thermoelectric power plant is examined, 24 KV, 60 Hz power plant supplying power to an infinite bus through two infinite bus through two transmission lines, as shown in transmission lines, as shown in Figure 2 (Kundur, 1994). (Kundur, 1994).

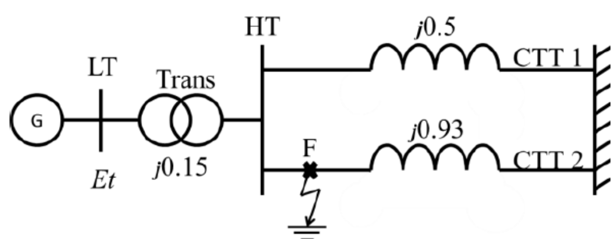

Figure 2 Infinite machine-bus power system

The initial condition of the system with quantities expressed in pu on a 2220 MVA and 24 kV basis are: Pm = Pe = 0.9, Q=0.436 (over-excited), Et =1.028.34º and EB 0.900810º . The equivalent generator of the system has a transient reactance of 0.3 pu and an inertia constant of 3.5 MJ/MVA without damping. The maximum pre-fault, fault and post-fault electrical powers are 1.351 pu, 0 pu and 1.1024 pu, respectively.

The simulation is performed for a period of 5 s with an integration step of 0.001 s, a fault application time of 1 s, and three fault release times of 0.07, 0.086, and 0.087 s.

Obviously, these input data are entered at their corresponding position on the left side of the graphical interface environment. The initial conditions of the power angle the initial conditions of the power angle and angular velocity change are 41.77 º and 0 rad/s, which are entered in the upper right panel. the upper right panel.

Once all the simulation data have been entered, the calculate button is pressed to present the results in the panel with this name and to obtain any of the three graphs offered by the application, selecting the one required. The results obtained from the simulation are presented and compared with those reported in the open literature in Table 3, while in Figure 3 and 4 the plots of the power angle as a function of time for the three fault release times and the plots of the electrical power as a function of the delta angle are presented, respectively.

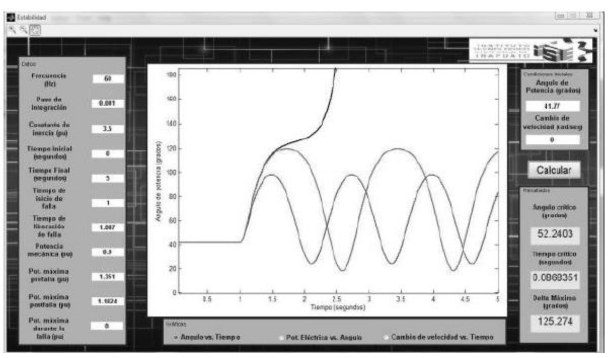

Figure 3 Power angle response for different values of fault release time

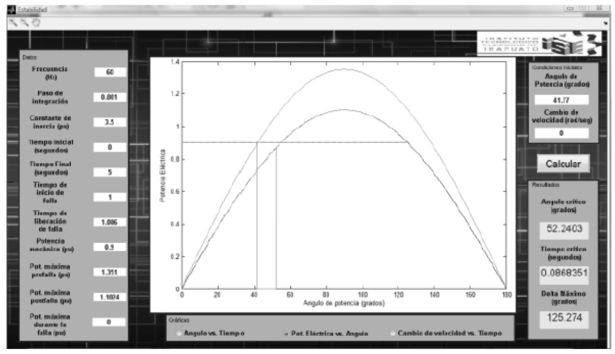

Figure 4 Electrical power diagram as a function of rotor angle

Table 3 shows that the implementation proposed in this work is reliable to carry out the TE analysis of SEPs, since the data obtained by such implementation are very similar to those reported in (Kundur, 1994).

In addition, it is shown that the critical release time is 0.0868351 s, so that with any fault release time greater than the above the system will lose stability. In Figure 3, the lowest and highest amplitude curve corresponds to the fault release times of 0.07 s and 0.086 s, respectively, while the curve that does not have sinusoidal behavior is 0.087 s, respectively. In this figure it is observed that the system is unstable or loses synchronism for the case in which the fault release time is 0.087 s, which confirms the above, while for the other two cases the electrical system maintains stability. It is important to mention that the power angle oscillates around the new operating point of the machine because damping windings are not being considered, see Figure 4.

It should be emphasized that this section has only shown how the application is used and has not illustrated how the code is modified, since this topic is too broad to be explained here, however, it is clear that electrical engineering teachers and students should not have problems to carry out such modifications because they are familiar with Matlab programming codes. In practice, excellent student performance has been observed when the teacher teaches various numerical integration methods before using the ET educational application, so it is recommended to do this to increase the educational effect that the proposed application has.

Conclusions

An educational computational application for the analysis of Transient Stability of electrical power systems has been presented. The proposed application was designed based on the five dimensions of knowledge and was developed as a Graphical User Interface in Matlab using a visual programming environment known as GUIDE offered by that package. The RTI combined with the Newton-Raphson method was used for the numerical solution of the DE system associated with the TE model, however, students have an excellent performance when the teacher teaches various numerical integration methods before using the TE educational application, so it is recommended to do this to increase the educational effect that the proposed application has.

The article illustrated how to use the proposed application, which has a friendly, intuitive and easy to handle user interface. This feature gives it the potential to be used in classroom or even in distance education courses of all subjects related to computer aided analysis of power systems. With the use of the tool, results are obtained in a short time, but thanks to its flexibility students can integrate their own solution methods, so that students not only acquire cognition, but also the competence of analysis and application of knowledge. Therefore, with the use of novel tools, such as the one presented in this work, it is possible to change in a dimensional way the traditional teaching of engineering education, since students acquire knowledge in a simpler way and learn to apply it in the innovative solution of problems, developing competencies for the management of work situations.

Finally, it should be mentioned that the proposed educational application is free to use and is open to any modification or improvement, so it is possible to acquire the tool by the person who wants it, whether student or teacher. To do so, it is necessary for the interested person to contact any of the authors of this work or through the web page of the authors' institution of origin www.itesi.edu.mx, where he/she will receive the appropriate attention.

References

Acarnley, P. (2005). A Power System Load Flow Analysis using an Excel Workbook. *International Journal of Electrical Engineering Education*, 42(2), 185-202.

AIEE Subcommittee on Interconnections and Stability Factors. (1926). First report of power system stability. *AIEE Trans.* 51–80.

Ayasun, A, Nwankpa, C. O & Kwatny, H. G. (2006). Voltage Stability Toolbox for Power System Education and Research. *IEEE Transactions on Education*, 49(4), 432-442.

Corderoy, B., Karady, G. & Papazoglou, T. (2000). Electric power engineering education. *ELECTRA*, 192, 18-22.

Güney, I., Koçyiğit, G. & Onat, N. (2014). Educational software for power system analysis. *International Journal of Electrical Engineering Education*, 51(2), 134-145.

Gutiérrez , J. J. (2007). *Diseño Curricular Basado En Competencias*. Viña del Mar, Chile: Ediciones Altazor.

Islam, S. & Chowdhury, N. (2001). A case-based windows graphic package for the education and training of power system restoration. *IEEE Trans. Power Systems*, 16(2), 181-187.

Kundur P., Paserba J., Ajjarpu V., Andersson G., Bose A., Cañizares C., Hatziargyriou N., Hill D. Stankovic A., Taylor C., Van Cutsem T. y Vittal V., (2004). Definition and classification of Power System Stability. IEEE Transactions on Power Systems, 19(2), 1387-1401.

Kundur, P. (1994). Power System Stability and Control. New York: McGraw Hill.

Larsson, M. (2004). ObjectStab- an educational tool for power system stability studies. IEEE Trans. Power Syst., 19 (1), 56–63.

Lee, C. H., Hsu, S. H, Lin, T. C., Kang, M. R. & Huang, G. (2001). Enhancing power engineering education through the use of power system simulator. IEEE-Power Engineering Society Winter Meeting, 3, 1467-1472.

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Levi, V. A. & Nedic, D. P. (2001). Application of the optimal power flow model in power system education. IEEE Trans. Power Systems, 16(4), 572-580.

Marzano, R. J., Pickering, D & McTighe, J. (1993). Assessing Student Outcomes: Performance Assessment Using the Dimensions of Learning Model. Alexandria: ASCD

Omer, M. & Idowu P. B. (2011). A platform-independent learning tool for power system analysis concepts. International Journal of Electrical Engineering Education, 48(4), 423-433.

Overbye, T. J., Sauer, P. W., Marzinzik, C. M. & Gross, G. (1995). A user-friendly simulation program for teaching power system operations. IEEE Trans. Power Systems, 10 (4), 1725–1733.

Rafian, M., Sterling, M., & Irving, N., (1987). Real Time Power System Simulation. IEE Proceedings C (Generation, Transmission and Distribution), 134(3), 206-223.

Saadat, H. (2010). Power System Analysis. New York: PSA Publishing.

Shin, J. R., Lee, W. H. & Im, D. H. (1999). A Windows-based interactive and graphic package for the education and training of power system analysis and operation. IEEE Trans. Power Systems, 14 (4), 1193-1199.

Singh, S. N. (2001). Challenges and initiatives in power engineering education. IEEE Computer Appl. Power, 14(2), 36–14.

Steinmetz, C. P. (1920). Power control and stability of electric generating stations. AIEE Trans., 39(2), 1215–1287.

The MathWorks, Inc. Matlab Optimization ToolboxUser's Guide Version 2, 2001. Natick, MA: USA. Recuperado de http://www.mathworks.com.
Vassell, G. S. (1991). Northeast blackout of 1965. IEEE Power Engineering Review, 11(1), 4–8.

Vournas, C., Potamianakis, E., Moors, C. & Cutsem, T. (2004). An educational simulation tool for power system control and stability. IEEE Trans. Power Syst., 19 (1), 48–55.

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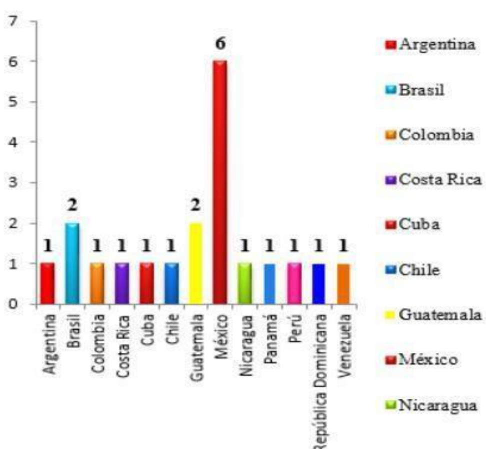

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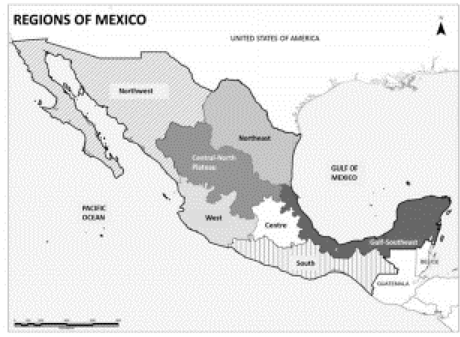

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