Analysis of problem-based learning impact on academic performance according to the forgotten(fuzzy) effects theory

Análisis del impacto del aprendizaje basado en problemas en el rendimiento académico según la teoría de los efectos olvidados (difusos)

Javier Bernardo Cabrera-Mejía; Pedro C. Martínez-Suárez; Andrés Alexis Ramírez-Coronel; María Luisa Montánchez-Torres; Esteban Torracchi-Carrasco; Fabian Leonardo Castro-Ochoa

[1]*Universidad Católica de Cuenca, Laboratorio de Simulación en Tiempo Real, Cuenca, Ecuador*
[2]*Universidad Católica de Cuenca, Laboratorio de Psicometría, Cuenca, Ecuador.*
[3]*Universidad Católica de Cuenca, Facultad de Odontología, Cuenca, Ecuador.*
[4]*Universidad Católica de Cuenca sede Azogues, Facultad de Enfermería, Azogues, Ecuador.*
[5]*Universidad Católica de Cuenca, Facultad de Psicología Clínica, Cuenca, Ecuador.*
[6]*Universidad de Valencia, España.*
[7]*Universidad de Oviedo, España.*
[8]*Universidad Católica de Cuenca, Centro de Investigación, Innovación y Transferencia de Tecnología (CIITT), Cuenca, Ecuador.*

**Correspondence: jcabreram@ucacue.edu.ec*

Received/Recibido: 06/28/2020 Accepted/Aceptado: 07/15/2020 Published/Publicado: 09/09/2020

DOI: 10.5281/zenodo.4262730

Abstract

In a globalized, demanding, and virtualized environment, uncertainty is part of the academic performance. This condition affects all schools irrespective the education level, size, or location, and therefore the tendency to suffer the consequences of the volatility of phenomena, including the change rate in methodological strategies. In the present work, the factors that motivate the exposure of higher education centres are identified, using a model based on the principles of fuzzy or diffuse subsets, called the Forgotten (fuzzy) Effects. This methodology has allowed the gathering of qualitative information, derived from the appreciation of a group of experts, whose knowledge comes from daily experience. This characteristic gives it the empiricism necessary for a scientific contextualization. It has been found that factors such as a) lack of information, b) poor curricular planning, c) teacher's attitude, though other factors such as the hourly load, the lack of research culture, motivation and the constant changes of public policies, influence the exposure of schools to unforeseen variations of the methodological type.

After determining the factors intervening in academic performance, the Problem-Based-Learning model was applied in the Engineering field; the average of the graduation subjects' examination (taken from 2017 to 2020), and the integration projects, showed 15% improvement in academic performance. This evidences that cause-effect factors such as the very theoretic management, or its contents, do not contribute to the enhancement of the students' graduation profile; neither they offer real solutions to the society.

Keywords: Academic performance, forgotten effects, fuzzy logic, Problem-Based Learning, Learning outcomes.

Resumen

En un entorno globalizado, exigente y virtualizado, la incertidumbre forma parte del rendimiento académico. Esta condición afecta a todas las escuelas, independientemente del nivel de educación, el tamaño o la ubicación, y por lo tanto la tendencia a sufrir las consecuencias de la volatilidad de los fenómenos, incluida la tasa de cambio de las estrategias metodológicas. En el presente trabajo se identifican los factores que motivan la exposición de los centros de enseñanza superior, utilizando un modelo basado en los principios de los subconjuntos difusos o difusos, denominados Efectos Olvidados (difusos). Esta metodología ha permitido reunir información cualitativa, derivada de la apreciación de un grupo de expertos, cuyo conocimiento proviene de la experiencia cotidiana. Esta característica le da el empirismo necesario para una contextualización científica. Se ha comprobado que factores como a) la falta de información, b) la mala planificación curricular, c) la actitud de los profesores, aunque otros factores como la carga horaria, la falta de cultura de investigación, la motivación y los cambios constantes de las políticas públicas, influyen en la exposición de las escuelas a variaciones imprevistas de tipo metodológico.

Tras determinar los factores que intervienen en el rendimiento académico, se aplicó el modelo de aprendizaje basado en problemas en el campo de la ingeniería; el promedio de los exámenes de las asignaturas de graduación (realizados entre 2017 y 2020), y los proyectos de integración, mostraron una mejora del 15% en el rendimiento académico. Esto evidencia que los factores de causa-efecto como la gestión muy teórica, o sus contenidos, no contribuyen a mejorar el perfil de graduación de los estudiantes; tampoco ofrecen soluciones reales a la sociedad.

Palabras clave: Rendimiento académico, efectos olvidados, lógica difusa, aprendizaje basado en problemas, resultados del aprendizaje.

Introduction

From an epistemological point of view, the social sciences have been severely criticized, among other things, because of their lack of analytical support in assessing the effectiveness of their practices, and their mistrusting on a data-based logic[1]. This type of reasoning, common in other sciences allows generating explaining and predictive higher power contributions.

According to Gil Lafuente et al.[2,3], all events, phenomena and facts surrounding the human being are integrated into a system, so it is inferred all the activity that takes place in it, the incidence of cause-effect influences it. For example, according to Rico and Arandes[4], a rainy day will have unfavourable effects on the traffic flow, and the food and cold beverage sales. On the other hand, it will have a favourable impact for some crops; for the umbrella's commerce, the reservoirs filling in hydroelectric power generation plants, among others. However, even with an impeccable system of planning and control, in real life, there is always the possibility of voluntarily or unwittingly ignoring or forgetting some causal relationships that are not still clear, and therefore not perceived in the processes of analysis and problem-solving.

In this process of cause-effect incidence, relations are recurrent. Therefore, it is possible to associate occurrence with the idea of the function, and it is present in all the activities and actions carried out in the company. Since all the processes existing in the different functional areas of the company are carried out sequentially so that the incidents transmit in a linked manner, it is widespread to omit some stages voluntarily and involuntarily. The incidence is associated with the idea of one group of entities effects on another one, or on itself. Likewise, this concept is related to the idea of a function and is present in all living beings' actions.

The method applied in the evaluation processes of Ecuador's HEIs, since Constituent Mandate No. 14, issued by the Constituent Assembly in 2008, is the so-called Multi-criteria Decision Method (MDM), a branch of mathematics applied to cases where there are vaguely structured problems[4].To reliably assess learning outcomes, we used the fuzzy logic or forgotten effects model. For quality assessment purposes in an exam is established for Ecuadorian students attending the last level of university programs or careers. This test is designed and applied by the Council for Quality Assurance in Higher Education (CACES). The examination focuses on the knowledge established for the respective program or career. If more than 60 per cent of students in a degree program fail to pass the exam for two consecutive years, the degree program will be automatically abolished by CACES, without prejudice to the application of the other evaluation and accreditation processes provided for in the Constitution, the Act, and its general implementing regulations[4]. The results of the examination do not affect the student's final average grades and qualifications. If a course or program is closed, the higher education institution may not open new promotions of these programs in ten years, without prejudice to ensuring that students already enrolled complete their cycle or year of study[5].

According to Article 11 of the Organic Law on Higher Education regulations[6], the CACES will design and apply the national exam to evaluate careers and academic programs for senior students at least every two years. This exam results will be considered for scholarships awarding for fourth-level studies and entry into public service[4,6].

The structure of the final exam is composed of two components: a) General competencies. -They refer, as well as the basic ones, to those that are indispensable to continue learning throughout life, incorporate into the working world; and, b) Specific competences. -They are the ones that are specific to the different subjects[7].

Forgotten Effects Theory

The phenomena and events that are perceived do not happen in isolation; instead, they are part of systems or subsystems; this means that in every activity, the cause-effect incidence is present in some way[8,9]. Even with a coherent control system, there is the possibility of forgetting causality relationships that are sometimes implicit. Naturally, the relations of incidence remain hidden since it is a question of effects on effects, provoked by a cumulus of causes. It is then necessary to use tools that allow the establishment of a technical base that perceives all the information and allows its contrast with data obtained from the environment so that direct and indirect causality relations are collected[10,11].

The discarding of a stage involuntarily occurs because, in sequential processes, the incidents are transmitted in a linked manner. Each one of these omissions or "forgetfulness" implies secondary effects that affect the set of incidence relations in a combined approach[12,13].

Advocacy, as a concept, is related to that of function and is also mostly subjective. Although difficult to measure, impact analysis makes a significant contribution to decision-making.

The theory of forgotten effects begins by considering that there are two sets of elements given as:

$$A = \{a_i | i = 1,2,\cdots,n\}$$
$$B = \{b_j | j = 1,2,\cdots,m\}$$

Whereas there is an effect of (a_i) on (b_j), if the value of the characteristic function of pair membership (a_i, b_j) is evaluated to [0,1]. Therefore, the degree of incidence of each (a_i) on (b_j) is expressed through the function.

$$\mu: AXB \rightarrow [0,1]$$

So that:

$$\forall(a_i, b_j) \in AXB;\ \mu(a_i,b_j) \in [0,1)$$

Where μ represents the values of the Cartesian plane formed by the set of pairs of elements evaluated, defining the direct incidence matrix (figure 1), through which the cause-effect relationships that occur with different degrees between the elements of (A)- causes and the elements of (B)- effects are shown.

Figure 1. Direct Incident Matrix

$$M = \begin{array}{c|ccccccc} & b_1 & b_2 & b_3 & b_4 & \cdots & b_n \\ \hline a_1 & \mu_{a_1 b_1} & \mu_{a_1 b_2} & \mu_{a_1 b_3} & \mu_{a_1 b_4} & \cdots & \mu_{a_1 b_n} \\ a_2 & \mu_{a_2 b_1} & \mu_{a_2 b_2} & \mu_{a_2 b_3} & \mu_{a_2 b_4} & \cdots & \mu_{a_2 b_n} \\ a_3 & \mu_{a_3 b_1} & \mu_{a_3 b_2} & \mu_{a_3 b_3} & \mu_{a_3 b_4} & \cdots & \mu_{a_3 b_n} \\ a_4 & \mu_{a_4 b_1} & \mu_{a_4 b_2} & \mu_{a_4 b_3} & \mu_{a_4 b_4} & \cdots & \mu_{a_4 b_n} \\ a_5 & \mu_{a_5 b_1} & \mu_{a_5 b_2} & \mu_{a_5 b_3} & \mu_{a_5 b_4} & \cdots & \mu_{a_5 b_n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_n & \mu_{a_n b_1} & \mu_{a_n b_2} & \mu_{a_n b_3} & \mu_{a_n b_4} & \cdots & \mu_{a_n b_n} \end{array}$$

Materials and Methods

The general aim of this investigation proposes to study the causal relationships present in academic performance, divided into the following specific objectives.

1. To systematize the theoretical elements related to academic performance and the proposed analysis tool, the Forgotten Effects Theory.

2. To analyze the existing causal relationships in the negotiators' performance, in a case study.

To this aim, the structure of this research has three sections: the third and last epigraph, applies this theory to the analysis of academic performance in the Catholic University of Cuenca, selected as a case study.

The main contribution of the proposal lies in the extrapolation of the forgotten effect's theory to the field of education.

Primary and secondary sources of information were used to elaborate the theoretical epigraphs and revise the university documents taken as a case study. The primary sources used were unstructured interviews with university students to complement the methodological analysis results and the application of surveys to teachers for the implementation of the theory of the forgotten (Fuzzy) effects.

Results

The case of analysis is the application of problem-based learning as a teaching and learning methodology to improve academic performance and, therefore, the exit profile of the students attending the Catholic University of Cuenca in Ecuador. A set of subjects and learning results in the Engineering field were selected for this purpose.

Initially, a list of learning results and educational objectives was prepared to carry out the analysis. After this stage, a panel of 10 expert teachers related to the area of studies was selected to evaluate the list of selected elements.

Table 1. List of causes (educational objectives - EO) and effects (learning outcomes - LO).

	Causes		Effect
EO_1	To develop and correctly manage electrical projects for the generation, transport, and distribution of electrical energy.	LO_1	Apply the CCBB in the career.
EO_2	Develop public and decorative lighting projects	LO_2	Identifies and defines problems
EO_3	Develop, implement and correctly manage engineering projects	LO_3	Feasibility of evaluating and selecting alternative solutions
EO_4	Successfully apply the concepts of efficient use and saving of electrical energy	LO_4	Formulate problems
EO_5	Adequately develops power quality analyses	LO_5	Problem-solving
EO_6	To correctly create the coordination of insulation and protection of electrical power systems	LO_6	Uses specialized tools
EO_7	Desarrollar apropiadamente sistemas de automatización y control industrial de procesos	LO_7	Cooperation and communication skills
EO_8	Adequate use of telecommunications as a tool for the automation of industrial processes, as well as the generation, transport, and distribution of electricity.	LO_8	Strategic capacity and operation
EO_9	Use mathematical, physical, chemical, and computer tools to analyze, model, and resolve environmental variables and problems.	LO_9	Understands professional, ethical responsibility
EO_{10}	Actively apply the principles of ecology and environment in projects related to their career development	LO_{10}	Assumes knowledge of professional codes
EO_{11}	Respectfully demonstrate an understanding of codes of ethics for the practice of their profession	LO_{11}	You have sufficient, written communication.
		LO_{12}	You have effective oral communication.
		LO_{13}	You have effective digital communication.
		LO_{14}	Commit to continuous learning.
		LO_{15}	Knows the contemporary environment

Source: Author

The objective is to obtain an incidence matrix that reflects not only direct causal relationships but also those that, de- spite not being evident, exist and are sometimes funda- mental for the appreciation of phenomena. To achieve this objective is necessary to establish the devices that make possible the fact that different causes can have effects on themselves and, at the same time, to take into account that some effects also can give rise to incidences on them- selves. Thus, it is necessary to build two more incidence relationships, which will include the possible effects that derive from relating causes to each other and the effects on each other.

Table 4. Matrix of causes (A).

	EO_1	EO_2	EO_3	EO_4	EO_5	EO_6	EO_7	EO_8	EO_9	EO_{10}	EO_{11}
EO_1	1	0.9	0.8	0.5	0.7	0.7	0.6	0.2	0.3	0.1	0.1
EO_2	0.9	1	0.7	0.8	0.7	0.4	0.3	0.1	0.1	0.1	0.1
EO_3	0.8	0.7	1	0.6	0.4	0.9	0.7	0.1	0.1	0.1	0.1
EO_4	0.5	0.8	0.6	1	0.8	0.6	0.5	0.1	0.1	0.1	0.1
EO_5	0.7	0.7	0.4	0.8	1	0.8	0.6	0.1	0.1	0.9	0.1
EO_6	0.7	0.4	0.9	0.6	0.8	1	0.5	0.1	0.1	0.0	0.7
EO_7	0.6	0.3	0.7	0.5	0.6	0.5	1	0.9	0.7	0.0	0.0
EO_8	0.2	0.1	0.1	0.1	0.1	0.1	0.9	1	0.8	0.1	0.6
EO_9	0.3	0.1	0.1	0.1	0.1	0.1	0.7	0.8	1	0.1	0.1
EO_{10}	0.1	0.1	0.1	0.1	0.9	0.0	0.0	0.1	0.1	1	0
EO_{11}	0.1	0.1	0.1	0.1	0.1	0.7	0.0	0.6	0.1	0	1

Source: Author

Table 5. Matrix of effects *(B)*.

	LO_1	LO_2	LO_3	LO_4	LO_5	LO_6	LO_7	LO_8	LO_9	LO_{10}	LO_{11}	LO_{12}	LO_{13}	LO_{14}	LO_{15}
LO_1	**1**	0.7	0.9	0.8	0.9	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.5	0.7
LO_2	0.7	**1**	0.9	0.9	0.9	0.5	0.2	0.7	0.1	0.1	0.6	0.1	0.5	0.6	0.8
LO_3	0.9	0.9	**1**	0.9	0.5	0.6	0.5	0.4	0.1	0.1	0.7	0.2	0.6	0.8	0.9
LO_4	0.8	0.9	0.9	**1**	0.9	0.6	0.5	0.1	0.1	0.1	0.8	0.6	0.8	0.8	0.9
LO_5	0.9	0.9	0.5	0.9	**1**	0.9	0.8	0.6	0.9	0.5	0.8	0.9	0.7	0.6	0.9
LO_6	0.5	0.5	0.6	0.6	0.9	**1**	0.3	0.1	0.6	0.1	0.7	0.3	0.9	0.8	0.9
LO_7	0.1	0.2	0.5	0.5	0.8	0.3	**1**	0.1	0.2	0.1	0.3	0.9	0.6	0.5	0.9
LO_8	0.1	0.7	0.4	0.1	0.6	0.1	0.1	**1**	0.1	0.1	0.6	0.8	0.7	0.7	0.7
LO_9	0.1	0.1	0.1	0.1	0.9	0.6	0.2	0.1	**1**	0.9	0.8	0.2	0.7	0.6	0.9
LO_{10}	0.1	0.1	0.1	0.1	0.5	0.1	0.1	0.1	0.9	**1**	0.7	0.1	0.8	0.6	0.9
LO_{11}	0.1	0.6	0.7	0.8	0.8	0.7	0.3	0.6	0.8	0.7	**1**	0.6	0.8	0.7	0.9
LO_{12}	0.1	0.1	0.2	0.6	0.9	0.3	0.9	0.8	0.2	0.1	0.6	**1**	0.7	0.9	0.9
LO_{13}	0.3	0.5	0.6	0.8	0.7	0.9	0.6	0.7	0.7	0.8	0.8	0.7	**1**	0.9	0.9
LO_{14}	0.5	0.6	0.8	0.8	0.6	0.8	0.5	0.7	0.6	0.6	0.7	0.9	0.9	**1**	0.9
LO_{15}	0.7	0.8	0.9	0.9	0.9	0.9	0.9	0.7	0.9	0.9	0.9	0.9	0.9	0.9	**1**

Source: Author

Once the matrices [M], [A] and [B], are constructed, the direct and indirect incidences are established; that is, incidences in which, at the same time, some interposed cause or effect intervenes. The composition or the max-min convolution of the three matrices was done, by using the array with the fuzzy rules.

Table 6. Fuzzy Rules

	NG	***N***	***Z***	***P***	***PG***
	NG	N	N	N	Z
	N	N	N	Z	P
Z	N	N	Z	P	PG
P	N	P	P	PG	PG
	Z	PG	P	PG	PG

Source: Author

$$(EO_1 \cap EO_1 \wedge EO_1 \cap LO_1) \vee (EO_1 \cap EO_2 \wedge EO_2 \cap LO_1) \vee (EO_1 \cap EO_3 \wedge EO_3 \cap LO_1)$$
$$\vee (EO_1 \cap EO_4 \wedge EO_4 \cap LO_1) \vee (EO_1 \cap EO_5 \wedge EO_5 \cap LO_1)$$
$$\vee (EO_1 \cap EO_6 \wedge EO_6 \cap LO_1) \vee (EO_1 \cap EO_7 \wedge EO_7 \cap LO_1)$$
$$\vee (EO_1 \cap EO_8 \wedge EO_8 \cap LO_1) \vee (EO_1 \cap EO_9 \wedge EO_9 \cap LO_1)$$
$$\vee (EO_1 \cap EO_{10} \wedge EO_{10} \cap LO_1) \vee (EO_1 \cap EO_{11} \wedge EO_{11} \cap LO_1)$$

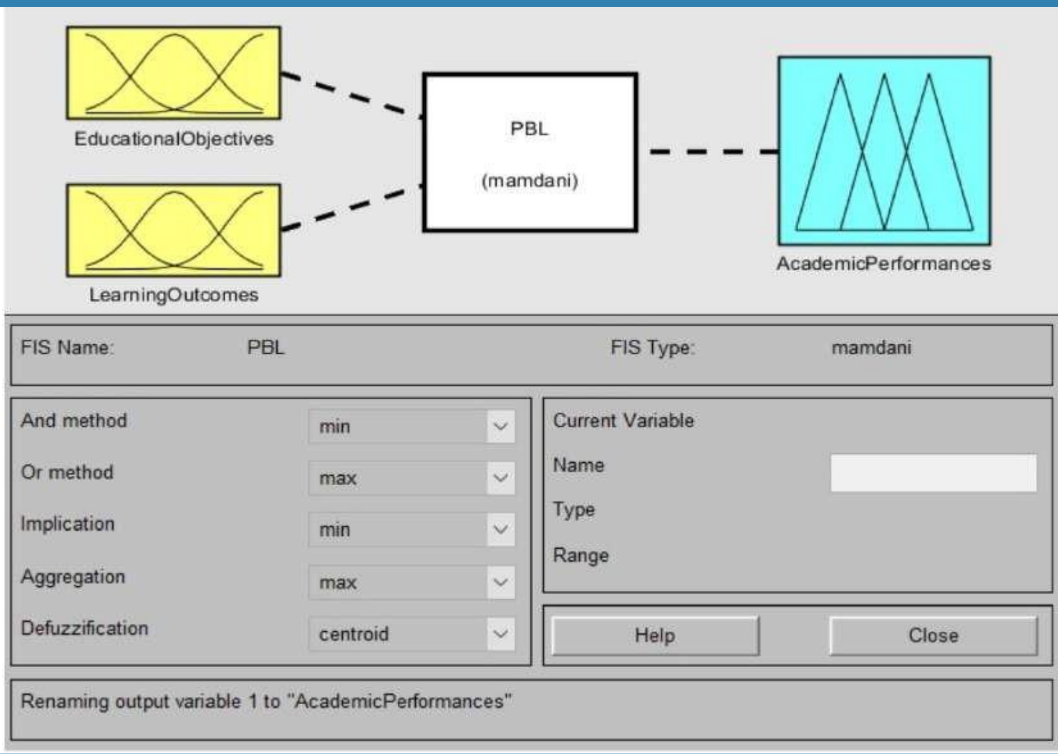
$$(1.0 \wedge 0.1) \vee (0.9 \wedge 0.1) \vee (0.8 \wedge 0.9) \vee (0.5 \wedge 0.5) \vee (0.7 \wedge 0.2) \vee (0.7 \wedge 0.7)$$
$$\vee (0.6 \wedge 0.8) \vee (0.2 \wedge 0.3) \vee (0.3 \wedge 0.9) \vee (0.1 \wedge 0.1) \vee (0.1 \wedge 0.1)$$

From each pair obtained, select the lowest value:

$$\vee (0.8) \vee (0.5) \vee (0.2) \vee (0.7) \vee (0.6) \vee (0.2) \vee (0.3) \vee$$

Of the eleven results obtained, the largest (0.8) is taken and placed at the cause-effect intersection of matrix C.

Figure 1. Mandani Fuzzy Controller.



Source. Author

Table 7. Convolution matrix $C = conv(M, A)$

	LO_1	LO_2	LO_3	LO_4	LO_5	LO_6	LO_7	LO_8	LO_9	LO_{10}	LO_{11}	LO_{12}	LO_{13}	LO_{14}	LO_{15}
EO_1	0.8	0.9	0.9	0.8	0.9	0.9	0.6	0.9	0.7	0.9	0.3	0.3	0.8	0.9	0.9
EO_2	0.7	0.9	0.9	0.8	0.9	0.9	0.5	0.9	0.7	0.9	0.3	0.2	0.8	0.9	0.9
EO_3	0.9	0.9	0.8	0.9	0.8	0.7	0.7	0.8	0.6	0.7	0.3	0.2	0.9	0.9	0.9
EO_4	0.6	0.8	0.8	0.6	0.8	0.8	0.5	0.5	0.7	0.8	0.3	0.2	0.8	0.8	0.9
EO_5	0.7	0.9	0.8	0.9	0.9	0.7	0.6	0.7	0.7	0.7	0.3	0.2	0.8	0.8	0.9
EO_6	0.9	0.9	0.8	0.9	0.9	0.6	0.5	0.7	0.7	0.7	0.3	0.2	0.9	0.9	0.9
EO_7	0.8	0.9	0.9	0.9	0.8	0.9	0.9	0.7	0.6	0.7	0.7	0.9	0.9	0.9	0.9
EO_8	0.8	0.9	0.9	0.9	0.8	0.9	0.9	0.8	0.6	0.7	0.8	0.9	0.9	0.9	0.9
EO_9	0.9	0.9	0.7	0.9	0.9	0.9	0.7	0.9	0.2	0.7	0.9	0.7	0.7	0.9	0.9
EO_{10}	0.2	0.9	0.7	0.9	0.9	0.1	0.1	0.2	0.7	0.7	0.2	0.2	0.6	0.4	0.9
EO_{11}	0.7	0.8	0.5	0.9	0.7	0.6	0.6	0.2	0.9	0.8	0.9	0.6	0.7	0.7	0.7

Source: Author.

Table 8. Convolution matrix $C = conv(C, B)$.

	LO_1	LO_2	LO_3	LO_4	LO_5	LO_6	LO_7	LO_8	LO_9	LO_{10}	LO_{11}	LO_{12}	LO_{13}	LO_{14}	LO_{15}
EO_1	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.9	0.7	0.9	0.3	0.3	0.9	0.9	0.9
EO_2	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.9	0.7	0.9	0.7	0.7	0.9	0.9	0.9
EO_3	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.9	0.7	0.9	0.7	0.6	0.9	0.9	0.9
EO_4	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.9	0.8	0.9	0.8	0.6	0.9	0.9	0.9
EO_5	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.9	0.8	0.9	0.9	0.8	0.9	0.9	0.9
EO_6	0.9	0.9	0.8	0.9	0.9	0.7	0.6	0.7	0.7	0.7	0.7	0.6	0.9	0.9	0.9
EO_7	0.8	0.9	0.9	0.9	0.8	0.9	0.9	0.7	0.7	0.7	0.7	0.9	0.9	0.9	0.9
EO_8	0.8	0.9	0.9	0.9	0.8	0.9	0.9	0.8	0.7	0.7	0.8	0.9	0.9	0.9	0.9
EO_9	0.9	0.9	0.8	0.9	0.9	0.9	0.7	0.9	0.8	0.8	0.9	0.7	0.8	0.9	0.9
EO_{10}	0.9	0.9	0.7	0.9	0.9	0.9	0.7	0.9	0.7	0.7	0.9	0.7	0.7	0.9	0.9
EO_{11}	0.8	0.8	0.8	0.9	0.8	0.8	0.7	0.8	0.9	0.8	0.9	0.7	0.8	0.8	0.8

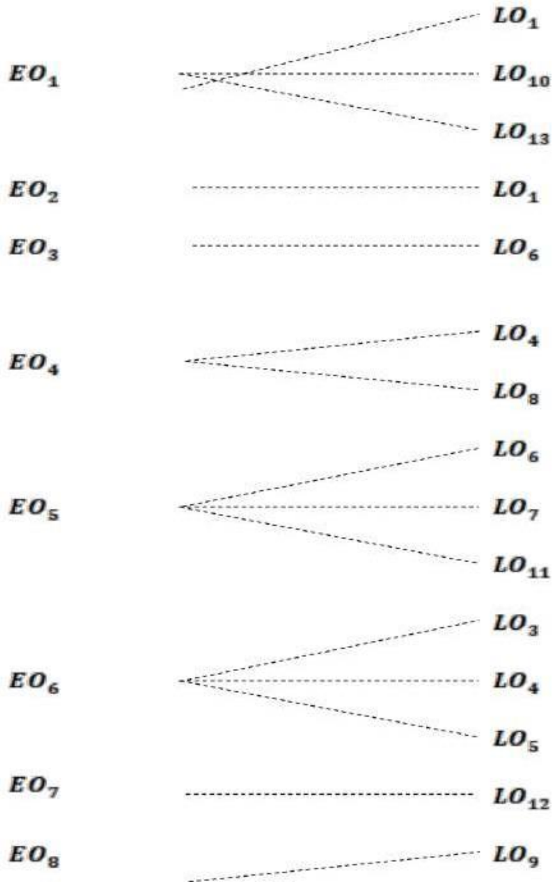
Source: Author.

Table 9. Forgotten (Fuzzy) effects matrix $EO = M^* - M$

	LO_1	LO_2	LO_3	LO_4	LO_5	LO_6	LO_7	LO_8	LO_9	LO_{10}	LO_{11}	LO_{12}	LO_{13}	LO_{14}	LO_{15}
EO_1	0.8	0.0	0.0	0.1	0.0	0.6	0.6	0.0	0.5	0.8	0.0	0.2	0.8	0.7	0.0
EO_2	0.8	0.4	0.2	0.3	0.1	0.0	0.4	0.4	0.4	0.0	0.6	0.5	0.1	0.0	0.1
EO_3	0.0	0.1	0.1	0.0	0.2	0.9	0.5	0.8	0.1	0.8	0.6	0.5	0.8	0.1	0.0
EO_4	0.4	0.2	0.1	0.8	0.1	0.2	0.2	0.8	0.6	0.7	0.6	0.5	0.2	0.2	0.0
EO_5	0.7	0.0	0.3	0.6	0.0	0.8	0.8	0.7	0.1	0.2	0.8	0.6	0.3	0.5	0.0
EO_6	0.2	0.0	0.7	0.7	0.7	0.1	0.4	0.6	0.6	0.1	0.4	0.5	0.0	0.0	0.1
EO_7	0.0	0.1	0.0	0.2	0.1	0.4	0.2	0.6	0.7	0.0	0.5	0.8	0.1	0.2	0.0
EO_8	0.5	0.0	0.4	0.0	0.0	0.0	0.0	0.6	0.7	0.6	0.7	0.0	0.0	0.0	0.0
EO_9	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.7	0.6	0.0	0.4	0.1	0.0	0.0
EO_{10}	0.8	0.0	0.0	0.0	0.0	0.8	0.7	0.8	0.0	0.0	0.7	0.5	0.6	0.7	0.0
EO_{11}	0.7	0.0	0.7	0.0	0.1	0.8	0.6	0.7	0.0	0.0	0.0	0.6	0.6	0.7	0.1

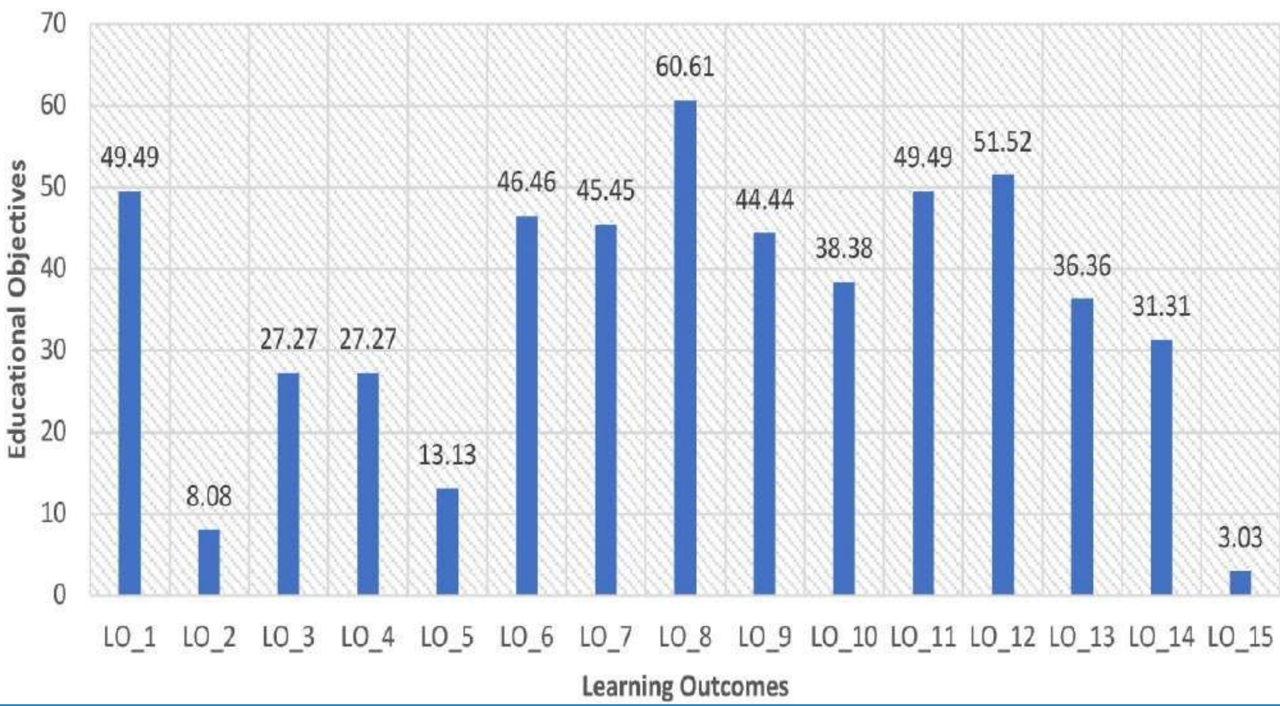
Fuente: Autor

Figure 2. The direct impact of educational objectives on learning outcomes.



Source. Author.

Figure 3. Relationship of educational objectives and learning outcomes.



Source. Author

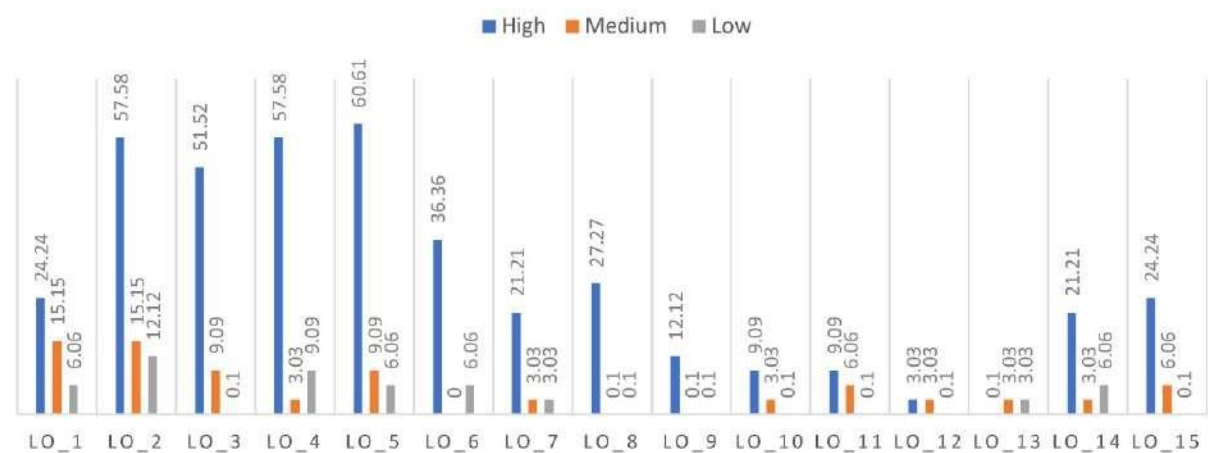
After analyzing Figure 3, the percentage of compliance with the Graduation Profile or the career educational objectives, for the period September 2016 - August 2017, is 35.49%, indicating that the learning results proposed for a career evaluation were not achieved; therefore, the results of the assessments are low (47% of students pass).

The next step is to analyze the contents of the syllabus, change the learning methodology, or update the curriculum's subjects. The application of the problem-based learning methodology takes place, and the results are those presented in Figure 4.

It is possible to demonstrate that the learning based on problems methodology, allowed to improve the learning-related results to identify, define, evaluate and formulate questions, as well as to select different alternatives for the solution of real-life situations. Nevertheless, also it was possible to identify that a problem exists at the moment of communicating the results either of written, oral or digital form.

The incorporation of ABP as a learning methodology allows us to unify the teachers and students' criteria, techniques, and rubrics, although some competencies or learning outcomes were not achieved. The tool used for measuring the learning results enables to identify the career's general weaknesses and to take the corrective improvement actions, providing a significant enhancement in the exit profile.

Figure 4. Percentage of programs contributing to learning outcomes. Source. Author.



Conclusions

The model allowed us to measure the percentage of fulfilment of the profile of graduation from the engineering degrees of the Catholic University of Cuenca.

It is essential to update the subjects' contents so that there is a contribution to the graduation profile.

Teacher training must be relevant to the subjects to contribute better to student performance.

The learning results must be specific, according to the geographical area.

For future research it is recommended that problem-based learning be used in various areas of knowledge, for example in Clinical Psychology[14,17] and Inclusive Education[15,18]. It would be important to conduct studies on problem-based learning in educational programs for children[19], adolescents, adults and older adults[16].

Author Contributions: Introduction, methodology and statistical analysis; preparation of the original draft of the manuscript; review and editing of the manuscript. All authors have read and accepted the published version of the manuscript.

Financing: This research received no external funding.

Conflicts of interest: The authors declare that there are no conflicts of interest.

References

1. Locke RM. The promise and limits of private power: Promoting labor standards in a global economy. Cambridge University Press; 2013.
2. Gil-Lafuente AM. Paula, LB. Una aplicación de la metodología de los efectos olvidados: Los factores que contribuyen al crecimiento sostenible de la empresa. Cuadern del CIMBAGE. 2010; 12(1):23-34
3. Gil-Lafuente AM González-Santoyo, F.; Flores-Romero, B. Teoría de los efectos olvidados en la incidencia de la actividad económica en la calidad de vida de los habitantes y cuantificación de los efectos para un reequilibrio territorial. Revista de Investigación en Ciencias y Administración. 2015;11(1):105-122.
4. Rico MA, Arandes JT. Matemática borrosa: algunas aplicaciones en las ciencias económicas, administrativas y contables. Contaduría Universidad de Antioquia. 2008;52(2):199-214.
5. Argudín Y. Educación basada en competencias. Nociones y antecedentes, Trillas, México; 2005.
6. Armein-Beardsley A. Methodological Concerns About the Education Value-Added Assessment System. Educat Measurement. 2008;37(1): 65-75.
7. Glazman R. Evaluación y exclusión en la enseñanza universitaria, Paidós Educador, México, 2001.
8. Rueda M. ¿Es posible evaluar la docencia en la universidad? Experiencias en México, Canadá, Francia, España y Brasil, ANUIES, México; 2004.

9. Levacic R. An Analysis of Competition and its Impact on Secondary School Examination Performance in England", Occasional Paper, No. 34, September, National Centre for the Study of Privatisation in Education, Teachers College, Columbia University, NY; 2001.

10. Lizasoain L, Joaristi L. Análisis de la dimensionalidad en modelos de valor añadido: Estudio de las pruebas de matemáticas empleando métodos no paramétricos basados en TRI, Rev. de Educ. 2009; 248:175-194.

11. Martínez-Arias R, Gaviria JL, Castro M. Concepto y evolución de los modelos de valor añadido en educación, Rev. de Educ. 2009;348(1):15-34.

12. Martínez-Arias R. Usos, aplicaciones y problemas de los modelos de valor añadido en educación, Rev. de Educ. 2009; 348 (1):217-250.

13. Thum YM. No Child Left Behind: Retos metodológicos y recomendaciones para la medida del progreso anual adecuado, Rev. de Educ. 2009; 348(1):67-90.

14. Ramírez-Coronel AA., Martínez-Suárez PC, Cabrera-Mejía JB, Buestán-Andrade PA, Torracchi-Carrasco E, Carpio MG. Habilidades sociales y agresividad en la infancia y adolescencia. Archivos Venezolanos de Farmacología y Terapéutica. 2020;39(2):209-214.

15. Ramírez AA. Laterality and reader process: correlational study. Espirales. 2019;3(27),105-117.

16. Pacurucu N, Rodríguez D, Puente C, Quito J, Armijos D, Carrasco E. Factores asociados a la desnutrición en grupo de adultos mayores en zonas rurales ecuatorianas. Archivos Venezolanos de Farmacología y Terapéutica. 2019;38(6),700-705.

17. González-Pando D, Beltrán García P, Martínez-Suarez PC. Exploring learning potential in schizophrenic inpatients in different psychopathological conditions. Clínica y Salud. 2016;27(2),88-95.

18. Montánchez-Torres ML, Martínez-Suarez PC, Jara-Saldaña G, García-Guevara W, Cedillo-Armijos M, Jaramillo-Ortiz F. (2019). Proyecto PHI: Funcionamiento intelectual límite o extremo inferior y dificultades de aprendizaje. Archivos Venezolanos de Farmacología y Terapéutica. 37(5),700-705.

19. Ramírez-Coronel AA, Ordoñez-Ochoa CE, Siguencia-Rodríguez DC, Abad-Martínez NI. (2020). Madurez neuropsicológica e indicadores antropométricos en niños de escuela básica. Sinergias educativas, 5(2),407-424.