ISSN 0798 1015

REVISTA ESPACIOS

HOME Revista ESPACIOS ÍNDICES A LOS AUTORES

EDUCACIÓN • EDUCAÇÃO • EDUCATION Vol. 38 (Nº 35) Año 2017. Pág. 5

Determining factors of competence-based learning: a case study in engineering

Factores determinantes sobre el aprendizaje basado en competencias: un caso de estudio en ingenierías

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Recibido: 30/03/2017 • Aprobado: 15/04/2017

Content

ABSTRACT:
This research analyzes factors that determine student learning when teaching focuses on skills development. The methodology employed by the teacher during the course was based primarily on flipped classroom. A linear regression model was used to evaluate competence-based learning. Research findings suggest that when teachers provide feedback based on learning, students adjust themselves, in a better measure, to the curricular objectives. Finally, research shows that quality of instruction is the determining factor in the process of development of learning competencies.
Key words Competencies, learning, engineering.

RESUMEN:
Esta investigación analiza los factores que determinan el aprendizaje cuando la enseñanza se centra en el desarrollo de competencias. Durante el curso se utilizó como metodología la enseñanza invertida y se definió un modelo de regresión lineal para evaluar el aprendizaje. Los resultados muestran que cuando el docente proporciona retroalimentación, los estudiantes se ajustan más fácilmente a los objetivos curriculares. Por último, se observa que la calidad de la enseñanza es el factor determinante del proceso de desarrollo de competencias.
Palabras clave Competencias. aprendizaje, ingeniería

1. Introduction

The decision to focus the teaching-learning process on the development of competences implies first clearly identifying the learning objectives (Zabala & Arnau, 2008) and then adapting the methodological strategy to them. Once progress has been made at this stage, the decisive process occurs in the classroom, where the teacher-student interaction takes place. It is in this scenario that variables – such as quality of instruction, dedication and motivation of the student, intellectual abilities of the student, among others – begin to play an important role (Salas Zapata, 2005; Tambingon, 2014).

Thus, it is fundamental to not only thoroughly review studies on competency-based learning, but also encourage active learning in the field of Engineering. In this sense, we can cite the work of (Trujillo Suárez & González Agudelo, 2010), who in their article on active learning in basic engineering courses propose didactic strategies that encourage active learning. The authors state that: "learning processes based on the construction of knowledge can be designed in a way that guarantees the assimilation of those same processes and promotes the autonomous intellect of the student" (2010, p.3).

On the other hand, in the study carried out by (Matos Chamorro, 2009), students under study stressed

that they had difficulties in adapting to the modalities of the institution, but that work to build competences strengthened both learning and research capabilities. In the Chamorro study, students state the advantages and disadvantages of the teaching-learning process and their competence-based evaluation. Traditional teaching, they assert, is not demanding, superficial, unstructured, with little call for research and in which the student is almost always only a listener. On the other hand, they comment that competence-focused teaching is reflexive, encourages research, is complemented by practice, there is a lot of student participation, it helps to work orderly and in itself, and leads to a deepening of knowledge.

In the engineering field we find the work of (OSPINO-CASTRO et al., 2016) whose applied new strategies for develop professional skills on photovoltaic systems. The authors argue that "these strategies search the development of skill through courses, gaining as result a solid experience in research aimed to develop photovoltaic technologies as classroom activities in order to keep a sustainability of the program" (p.10). The overall conclusion of the authors is that students learn more readily the procedures and use of elements described in the experiences.

Based on the above, and bearing in mind the Sergio Arboleda University School of Engineering's need to provide active methodologies that encourage the teaching of competences already defined in the work of (Morales Piñero & Ángel Acosta, 2016), it would be interesting to answer the following questions: What factors determine student learning when teaching based on skills? And what factors determine the development of competences in the teaching-learning process?

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2. Methodology

The main objective of the Research and Development Seminar is to stimulate and introduce the student in basic and applied scientific research in the field of engineering. The students in this class were completing their fifth semester as an Environmental, Systems, Electronic, or Industrial Engineer major at Sergio Arboleda University. As a curricular objective, the course proposes that students develop a research proposal applied to the field of engineering; as a learning objective, students strengthen the ability to formulate and solve problems using ethics as a basic pillar.

The methodology used by the teacher during the course was based mainly on flipped classroom (Tucker, 2012) and included lecture; support during class; the use of the virtual platform www.piazza.com to make course material available and interact with the students; a specialist-led review session; and active feedback on assignments. The first part of the course was more theory-based, given that it was an attempt to introduce students to the world of research, and used the text of (Chalmer, 2000), "What is This Thing Called Science?" as a guide. During this phase, students answered questions that developed each session's theme and then discussed in small groups before the teacher's explanation, which was further accompanied by comments from said groups.

During the second and third part of the course, the curricular objective focused on the development of a research proposal, to be presented in two submissions, A and B. Here, the methodological strategy included lectures for the more theoretical aspects, complemented by personalized monitoring of each group's work, given the wide variety of topics as a result of the different majors present in the course. More practical sessions included the use of available research software and resources (Scopus, ScienceDirect, Scimago, Mendeley, SPSS). These sessions were held in classrooms and computer labs, where students used their previous work.

The case study was conducted during the second semester of 2016 with 72 students grouped into two courses (Group 1: 40 students, Group 2: 32 students). Students worked in teams of two or three people throughout the semester and formulated 28 research proposals in total.

The evaluation system was divided into three periods. During the first period, evaluation was individual, given that the objective was to consolidate knowledge about the philosophy of science and the greater proportional weight was given to work that was developed during class sessions. During the second and third periods, evaluation was group-based, attempting to ensure that feedback generated learning. In these cases, the main weight was given to the research proposals. Students focused on developing their research proposals in both of these periods, and evaluation consisted of a comprehensive review of the form, structure, and content of the proposals.

In order to evaluate the achievement of the learning objectives, including the capacity to formulate and solve problems and the strengthening of ethics, the ethical capacity of the students was measured through an authorship review of their work and an experiment applied at the end of the course. With respect to the measurement of competence to formulate and solve problems, information was collected through two surveys and analyzed using a linear regression model.

To strengthen ethics in students, they were instructed about the importance of respecting authorship of works and the use of APA standards from the Mendeley reference manager. Students were informed that in order to verify the authorship of a work, said work would be revised using the platform http://turnitin.com/. The same procedure was followed for both of the research proposal submissions.

Finally, at the end of the course, an experiment was designed to evaluate ethical reinforcement in the students and validate the following research assumption: "When the teacher provides spaces that facilitate cheating, students, regardless of the grade they need, cheat." To do this, the teacher did a presentation for Group 1 that showed the research proposal that had received the highest grades and later applied a quiz where the student was asked his or her opinion about various and very basic parts of the presentation. Questions did not ask for an exact answer, but an opinion. As an incentive, a bonus of little significance was offered (an extra grade). After the quiz began, the teacher simulated a phone call and indicated to the students that he would have to momentarily step out of the classroom, leaving the first slide of the active presentation on the screen. In order to assess the behavior of the students, an infiltrated person was placed in charge of recording what happened in the classroom during the absence of the teacher.

To evaluate the strengthening of the competence related to the formulation and resolution of problems, a linear regression model was the defined methodological approach, where the dependent variable was competence-based learning and the independent variables were: quality of instruction, career average, student dedication and the application of knowledge, following the proposed methodology utilized by (Salas Zapata, 2005; Tambingon, 2014). Information showed in Table 1 was obtained through a semi-structured questionnaire that collected information about the variables using a Likert scale.

Table 1: Variables in the questionnaire

Sex	Woman ( ) Man ( )
Intellectual abilities	Career average
Quality of instruction	Clarity in explanation Openness to student participation Doubts clarification Availability of information sources
Student dedication	Timely attendance to classes Participation in class Preparation of classes Dedication in the preparation of the works
Application of knowledge	Application of the contents Connection of the R & D + I seminar with other subjects The proposal generates innovation and entrepreneurship
Competence-based learning	Skills needed to adequately formulate a problem knowledge needed to formulate the objectives Skills needed to organize a theoretical framework Learning about the use of APA standards

In order to achieve reliable answers, the anonymity of the participants was ensured by sending the questionnaire through an internet link to the emails of the 72 student participants at the end of the third period in 2016, of which 49 valid responses were received.

Finally, to evaluate the relevance and quality of the feedback activities, a final session of differentiated reinforcement was carried out for the two groups. In Group 1, the activity consisted in presenting a review

session directed by the Associate Professor, who integrated and related all of concepts seen during the course, in such a way as to strengthen the proposals that were being carried out. In Group 2, given that they had poorer results in the proposals, the activity was carried out with the same script, but this one was directed by another person in the team. In both cases, at the end of the activity a second survey was applied but this time, besides knowing the perception of the student about the acquired learning, he or she was also asked to rate the usefulness and quality of this special session.

3. Findings

Given that the first phase of the course was focused on strengthening the basic notions about research, part of the evaluation centered on the individual, although the group work was weighed heavily. The scores obtained by students at this stage were quite good with a mean and a standard deviation of 4.02 (0.47) for Group 1 and 3.70 (0.52) for Group 2, respectively. The grading scale ranges from 0.1 to 5.0.

For the second period, where the students had to submit Version A of their research proposal, scores were much lower (see Table 2) with a mean and standard deviation for Group 1 of 3.41 (0.89) and for Group 2 of 2.91 (1.22).

For the third period of the course, the proposals improved significantly and the scores evidence it, going from 3.18 in Version A to 3.74 in Version B. Likewise, the differences without the groups were reduced, which is evidenced in the decrease of the standard deviation of Version A (1.07) and Version B (0.97).

Table 2: Research proposal scores

Proposal	Group	Mean	N	Standard Deviation
A	01	3,4133	15	,89248
	02	2,9092	13	1,21719
	Total	3,1793	28	1,06632
B	01	3,9987	15	,67379
	02	3,4377	13	1,19541
	Total	3,7382	28	,97555

Apart from this, given that the authorship of the research proposals was verified by the platform http://turnitin.com/, three acceptance ranges were defined regarding the percentages of plagiarism defined by the software. The first range, catalogued as “Without Plagiarism,” went from 0% to 24%, assuming that the program has deficiencies in the criteria used. The second range, defined as “Plagiarism to be revised,” went from 25% to 45% and included a grading penalty. The third range, defined as “Serious Plagiarism,” was higher than 46% and included the cancellation of the proposal.

The results of the evaluation for Version A showed that for Group 1, 66.67% of the proposals placed in the first range, 26.67% placed in the second range and 6.67% in the third range. For Group 2, 15% were placed in the first range, 38.46% in the second range, and 15.38% in the third range. This result was the main factor that affected the scoring of the proposals.

Regarding the experiment related to ethics that was carried out at the end of the course, it was evidenced that the behavior expected as the “assumption of the researchers” was valid for 90% of the students. Furthermore, these students went beyond what was predicted.

Based on the official score that students have to perform in the university platform, at the moment of evaluating the Associate Professor of the course, it was observed that the students who obtained the highest grades (Group 1) evaluated the teacher with a lower score (3.89/5) and the students who obtained the lowest grades, but who were reinforced with diverse strategies, rated better the teacher´s work giving a higher score (4.15/5).

The results of the regression analysis indicate that the model offers a good fit and that, according to the results shown in Table 3, that 61% of learning is explained by the explanatory variables considered.

Table 3: Model summary b

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
,806a	,650	,627	1,65417	1,947

a. Predictors: (Constant), career average, student dedication, quality of instruction.

b. Dependent variable: Competence-based learning

According to the obtained results summarized in Table 4, it is observed that the factor that determines to a greater extent the process learning of competences in students is quality of instruction (0.688). This variable was positive and significant in the model. The variables "student dedication" and "career average", have a relevant contribution in the model, but are not significant. Finally, the variable "application of knowledge" was excluded in the model because it was not relevant in explaining the behavior of the dependent variable.

Table 4: Coefficients a

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-2,574	2,251		-1,144	,259
Quality of instruction	,580	,104	,614	5,575	,000
Student dedication	,267	,121	,250	2,200	,033
Career average	,966	,427	,217	2,261	,029

a. Dependent variable: Competence-based learning

At the end of the course a second survey was applied during a special reinforcement session differentiated for the two groups. Although the content of the session was the same, this time an unrelated teacher was invited to direct the session of group 2. In the survey only was asked to evaluate the usefulness of the session to reinforce the learning and the quality of it. A Liker scale from 1 to 5 was used and the results are shown in table 5.

Table 5: Results of differentiated reinforcement session

Quality of this special session		Usefulness of the reinforcement session			
Mean	Std Dev.	Mean	Std Dev.	N	Group
3,92	0,89	3,86	0,95	36	1
4,44	0,50	4,07	0,47	27	2

The results indicate that both groups rated the utility and quality of the session very positively, although group 2 stands out in the assessment. This can be due to the natural predisposition that the students can be formed towards the teacher of the subject. In fact, this assessment is directly related to the official

grade given by the students towards the teacher. It can also be deduced from the results that the incorporation of an external teacher can facilitate the reinforcement of learning.

4. Conclusions

From the analysis of the results obtained from the students, it is concluded that when teachers provide feedback based on learning, students adjust themselves, in a better measure, to the curricular objectives.

On the other hand, the research shows that when the teacher promotes spaces that facilitate cheating, students, independently of the grade they need, tend to make use of these opportunities.

It should be noted that when the teacher applies strategies focused on strengthening learning by competences, the students, independently of the grade obtained, positively recognize the effort of the teacher.

Finally, the results of the research show that the quality of instruction, defined as: clarity in the explanation of the contents, openness toward student participation, and availability to clarify doubts, is the determining factor in the process of the development of learning competencies. This finding makes it clear that, although the dedication of the student and his or her intellectual abilities are important, the teacher is the main element that assures the development of competencies.

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