COMUNIDADES VIRTUALES Y EL APRENDIZAJE ESTRATÉGICO DE CÁLCULO EN INGENIERÍA

VIRTUAL COMMUNITIES AND STRATEGIC LEARNING OF CALCULUS IN ENGINERY

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Este trabajo tenía por objetivo identificar los efectos de una comunidad virtual de estudiantes de ingeniería en el aprendizaje estratégico de Cálculo. Consistió en la implementación de una comunidad de alumnos de Cálculo I, soportada en la plataforma Moodle, bajo la modalidad b-learning, diseñada para el aprendizaje estratégico de esa asignatura. La investigación se realizó bajo un enfoque cuantitativo y alcanzó un nivel descriptivo. En el diseño, se estructuró un plan en dos partes: 1. investigación por encuesta y 2. pre-experimento. Los resultados revelan cambios significativos en pro de un desempeño más estratégico por parte de los miembros la comunidad.
Palabras claves: Tecnologías de la Información y la Comunicación, Innovación Pedagógica, Estrategias de Aprendizaje, Clase Experimental, Cálculo.

This work had as objective to identify the effects of an engineer student's virtual community in the strategic learning of Calculus. It consisted in the implementation of a Calculus I student's community, supported in Moodle platform under b-learning modality, designed for the strategic learning of this subject. The investigation was made under a quantitative approach and reached a descriptive level. During the design, it was structured a two parts plan: 1. survey investigation, and 2. pre- experiment. The results revealed significant changes in the strategic performance of community's members.
Keywords: Technology about Information and Communication, Educational innovation, Learning strategies, Experimental class, Calculus.

I. Introduction and bases of the research.

A new strategic learning approach emerges within the framework of the cognitive and constructivist theories. This approach proposes a permanent, effective and efficient learning that not only requires mastering conceptual and procedural specific knowledge in a topic (Calculus, for instance), but it also needs expertise when using some cognitive and metacognitive strategies as well as self-regulation capabilities and individual autonomy.

Although the authors who have worked on this strategic learning approach have not come to an agreement on one definition, they all

coincide significantly. It is inferred that in a strategic learning approach it is inappropriate to learn by trial and error, since it is necessary to know when, how and why we must activate certain knowledge in order to attain a learning goal in a specific situation and context. (Rios, 2003). Just as Del Mastro states (2005, p. 88), this means that strategic learning entails the progressive development of one's autonomy and the self-regulation of one's learning in order to consciously and intentionally choose the actions and knowledge one needs for achieving learning goals in certain teaching and learning situations.

Now, this strategy requires mastering both metacognitive and learning strategies which can and must be taught (Monereo & Castelló, 1997; Del Mastro, 2005; Poggioli, 2009). Studies have confirmed it; furthermore, current learning demands in our society -where information changes quickly and is available for everyone- call for it.

A review of previous research on the use of strategic approach in on-site education shows that all authors see it as a relevant tool for learning (Brunin; Schraw & Ronning, quoted by Ríos, 2003; Mayer, 2004; & others).

It is ironic to find that, despite it is vital to be able to carry on learning throughout life in this society, this skill cannot be thoroughly enhanced; students' educational deficiencies cannot be overcome in order to meet this requirement, neither in secondary education nor in higher levels (Perez, Pozo & Rodríguez, 2003; Labatut, 2004).

Specifically regarding higher education, Camarero, Martín & Herrero (2000) found out that low-performing students do not use strategies, but intuition. Conversely, high-performing students use metacognitive, control and social-affective strategies. Therefore, experimental and technical studies in university specializations need to improve their teaching of learning strategies related to their content.

However, virtual communities (VC) emerge as another resource that is provided by information and communication technologies (ICT). These communities not only provide an opportunity for group learning, in a permanent, cooperative and continuous way; they also create a interactive situation in which students can explain, foretell and express their own performance, granting a tool to go from external regulation to self-regulation of their learning. This transition is the key in the strategic learning approach.

Regarding virtual communities, Cabero (2006, p. 7) asserts that they are "communities of people who share common values and interests. They communicate with each other by using different communication tools provided by telematic networks, either synchronic or asynchronous networks".

Consulted sources related to this topic show that virtual communities can be classified according to different categories; yet the most relevant fact is the meaning that these communities can get to have in the learning process of individuals. In this respect, Cabero (2006, p.24) affirms that … learning in VC involves learning in groups and learning both in a cooperative and non-competitive way to which all members of community contribute by sharing their knowledge and perspective of problems, attaining common goals that can vary from the solution of a problem or project to the simple development of an activity.

Based on what it was stated above, it can be asserted that in a virtual learning community the need for communication and interaction is linked to the each member's purpose of attaining a common learning goal.

In this context, given the following elements: current learning demands, the development of the media and ICTs, the relevance of the strategic learning approach (proven in on-site teaching and learning), the poor performance and the high rate of students repeating the Calculus chair at the Faculty of Engineering of the Universidad Católica Andres Bello (UCAB), a question may be posed: how can a virtual community of engineering students contribute to the strategic learning of Calculus? Finding answers to this question was the motivation of this research.

The specific objectives of this research were: 1.Providing the characteristics that form a profile of a first-semester-engineering student who uses strategic learning of Calculus. 2. Identifying the characteristics that a virtual learning community must have, in order to allow its members to acquire a strategic learning of Calculus. 3. Designing and implementing a virtual learning community in order to provide students with a tool for the strategic learning of Calculus. Those specific objectives made it possible to attain the general objective: Identifying the effects of a virtual learning community of engineering students on the strategic learning of Calculus.

In order to attain the objectives, some aspects were determined based on the theoretical principles of: strategic learning, learning and metacognitive strategies, distance education, virtual learning environments, and virtual learning communities.

2. Method.

The methodology in this research was carried out based on a predominantly quantitative approach since its characteristic process of monitoring and tests was used, most of the gathered data was analyzed statistically, and the general objective of this research aims at identifying the effects of the virtual community to be implemented. For the research design, a two-part plan was devised:

2.1. Part I: Description of group A.

In this part of the research, group A was defined and described. It was used as one of the references to determine whether there was an effect of the virtual communities on the strategic learning of Calculus.

This group's population was the students that registered during the two semesters of the academic years 2006-2007 and 2007-2008 for the Calculus I chair of the Informatics Engineering School of the Universidad Católica Andrés Bello (UCAB), and *passed it at the first attempt*. Over the course of the four semesters mentioned above, it was found that the total population comprised eighty nine (89) students with a media proficiency average of 0.70 (averages vary from 0.40 to 1). A population sample[1] of 60 students was randomly selected, consisting of 23 women and 37 men between 17 and 23 years old (78% of the sample was constituted by students between 18 and 20 years old).

Data was gathered by using a question paper on the strategic learning of Calculus that measured the profile variable for the strategic learning of Calculus. The creation of this instrument was carried out based on the work of De la Fuente & Justicia (2003) and Camarero, Martín & Herrero (2000), authors that worked on the Acra scale.

2.2 Part II Design and application of the VC. Group B.

A virtual community was designed and implemented among a group of students from section 003 of the Calculus I course of Informatics Engineering of the UCAB (group B). It comprised 12 students who neither quit the class nor abandoned university: 3 women and 9 men, 5 eighteen-year-olds, 5 nineteen-year-olds, one seventeen-year-old and a twenty-two-year-old**.** Their proficiency average[2] was between 0.20 and 0.50 and 58% of them were repeating Calculus I for the third time.

A pre-test and post-test design was used in only one group. The stages developed in this part of the research will be described below.

2.2.1 Description of the VC.

During this stage, all necessary steps were taken in order to identify the characteristics that a virtual community must have, helping its members acquire a strategic learning of Calculus.

This identification was accomplished in two important ways:

a.Review of the literature on virtual learning communities, strategic learning, e-learning and b-learning. The following aspects were considered: 1) use of interrelated strategies (Bruning, Schraw & Ronning, quoted by Ríos, 2003); 2) combining strategies with the academic content that would be carried out (Monereo & Castelló, 1997; Monereo, 2000); 3) each topic was devised according to the methodological sequence for teaching learning strategies proposed by Del Mastro (2005); 4) in the implementation of the methodological sequence, pertinent methods were used according to each stage or phase (Pozo, Monero & Castelló, 2001; Del Mastro, 2005); 5) metacognition was developed through reflection and asking questions (Del Mastro, 2005; Poggioli, 2009); 6) guidelines for the instructional design in virtual learning environments proposed by Herrera (2006) were used; 7) the importance of the teacher's role in a virtual learning community was considered (Garrison & Anderson 2005), as Cabero & Llorente (2010, p.12) point out: «in this type of learning, the success of this experience depends on the involvement of the teachers». In this regard, as Levis (2011, p.11) states, teachers' roles are: «[to] contribute to their students' skill to produce knowledge in a collaborative manner, so they will be able to reach complexity levels that are hard to attain individually, but without neglecting the individual acquisition of knowledge and abilities on specific contents in that process». 8) During the creation of the virtual learning community, two clearly different moments[3], proposed by Adrian (2007), took place.

a. The description of group A in Part I, which aimed to design a virtual community that helped students repeating the course with the characteristic acquisition that was already identified in the successful Calculus I students.

2.2.2 Preparation for the VC design. Pre-test.

For the design stage, all the data which had been gathered was used during the description stage of the VC and the pre-test results of group B. Two aspects were studied: the technological and pedagogic aspects**.** In the first one, the learning platform Moodle was used because: «it has most of the tools related to communication and monitoring of the participant activities, … its main goal is

providing teachers with the best tools to manage and promote learning» (Marín & Maldonado, 2010, p.124.) Obviously, tools will be put to their best use only if the strategies designed by the teacher allow it. The design is easy to access and to use; in addition to that, it provides users with several tools and interactive and cooperative modules. The VC can be found in this URL: http://www.elauladelisset.com.

The pedagogic aspect was developed in two sub-stages. The first one is the pre-test[4] application aiming at making decisions on which learning strategies a virtual community must work with based on the literature review and the statistically considerable differences between group A and B. The second one is related to the creation of an instructional design that includes the creation of handouts, activity designs, monitoring and evaluation.

2.2.3 The VC for the strategic learning of Calculus

The virtual community was designed to explicitly work on storage strategies, use strategies, problem-solving strategies, metacognitive strategies, and conceptual and procedural knowledge of the Math required for learning Calculus.

To attain this goal, three topics were taught via online: 1) Derivative Rules. 2) Application of derivatives (tangent lines, a normal and a curve tangent and an angle between the two curves). 3) L'Hospital's, Rolle's, Lagrange's and Cauchy's theorems.

Tools were used in different formats (text, power point animations, flash and videos) besides from interactive (question papers) and cooperative tools (forums and wikis), as well as homework assignments.

Each topic was presented with a brief introduction in order to get the student acquainted with the content s/he would work with, a didactic handout[5], the tools for studying the conceptual and strategic content, and activities that varied from individual and interactive homework to cooperative activities like the forum and the wiki.

The work in the community was finished after the post-test was carried out and the students evaluated their experience.

2.3. Variables of the Research.

Independent Variable: Virtual Community for the strategic learning of Calculus. It is a teaching and learning experience developed by the b-learning model on the Moodle platform. With this instrument, interaction of community members (students and teacher) and the available resources allows the acquisition of contextualized strategies to learn Calculus.

This variable was put into practice by reviewing the individual and cooperative homework -whether they were interactive or not- that was created by the student members of the VC based on the created instructional design.

The strategies were: concept maps, comparative charts, and questions in the problem-solving stage, self-assessment through quizzes, and recognition of the basic math concepts which are vital for learning Calculus.

Dependent Variable: Profile for the strategic learning of Calculus. It refers to the application of some learning and metacognitive strategies as well as conceptual and procedural knowledge when learning Calculus.

This variable was put into practice in the question paper on the strategic learning of

Calculus. It measured: how many times students used acquisition, storage, use, and problem-solving strategies; metacognitive strategies when studying new concepts and solving calculus problems; and how often the knowledge regarding real numbers, algebraic expressions and trigonometric function was useful for learning Calculus.

3. Results.

The data gathered from the question paper on strategic learning of Calculus of groups A and B belongs to the ordinal categorical type[6]. Thereby, the data was used for interpreting results of the following descriptive statistics: mode, median, interquartile range and range. Microsoft Office Excel 2007 was used to tabulate them. The statistics software SPSS Statistics 17.0 was used for analyzing the results. Results were showed in charts and box plots[7].

Non-parametric statistics were employed because its theories were considered more appropriate to the type of data gathered in this research. Regarding this aspect, Siegel (1998) asserts that parametric tests entail several suppositions and without them, no probability affirmation obtained from these tests can be reliable. Among the advantages that the author mentions regarding non-parametric statistic tests are: a) probabilities obtained from most of those tests are accurate, no matter what the distribution of the population from which the sample was taken was; b) if the reason for the distribution of population for small samples[8] is unknown, there is no other choice; c) there are appropriate tests for studies in different populations, d) they are useful since researchers can compare their subjects by affirming that one of them is, to a greater or lesser extent, similar to another without specifying quantity.

3.1. Results of Part I: description of group A.

Applying a strategic learning Calculus requires the student to acquire specific knowledge of that topic, to be autonomous and self-regulated. Although the question paper did not measure autonomy, but how frequent certain learning and metacognitive strategies were, it is true that in general terms the use of strategies is related to academic success (De la Fuente & Justicia, 2000; Camarero, Martín & Herrero, 2000). Besides this, «repetitive failures of many students can be due, among other reasons, to the poor use of metacognitive and cognitive strategies» (Roman & Carbonero, 2002, p.168). Therefore, strategic learning requires, apart from other things, awareness of the process or technique, so that it can be effectively and efficiently used. Regarding this aspect, the results made it possible to offer a basic description of the group of surveyed students. This research did not intend to provide a lengthier description of this aspect.

Based on the results, it can be affirmed that surveyed students:

1. Use some strategies to solve problems, showing evidences of going through some stages such as: understanding (not only they can distinguish data from unknown numbers, but they also relate problems to the ones studied before); planning (before solving a problem, they think about the steps that have to be taken); and assessment (they assess the validity of the final result of the problem).
2. Use a metacognitive strategy to control and regulate their own cognition (they study Calculus in a place they can focus on)

3. Recognize that their acquired knowledge of math, especially when related to operations on real numbers and algebraic expressions, has allowed them to solve Calculus problems.

In addition to that, when using the non-parametric statistic test[9] of a Kolmogorov-Smirnov[10] sample (á=5%), it was inferred that in most of the questions of the used instrument, the surveyed students carefully thought about each item of the question paper[11].

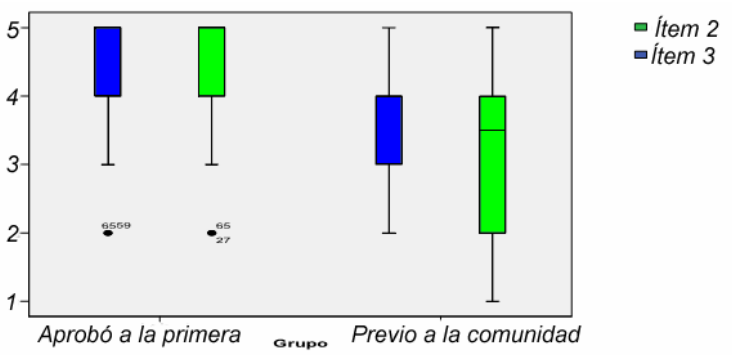
3.2. Part II Results: design and application of the VC. Group B.

3.2.1. Comparison between the question paper of group A and the post test of group B.

To analyze the results, descriptive statistics, mentioned in the beginning, were used, as well as the non-parametric contrast U-Test of Mann-Whitney[12] (á =5%) for independent and unpaired samples[13]. To analyze those samples, some items of the question paper on the strategic learning of Calculus were selected, thus providing a group A description. Nevertheless, descriptive analysis was limited to those items in which the U-test showed statically significant differences (p, <0.05). This happened in Item 2: "I study calculus in a place where I can focus on it" and Item 3: "I identify the data of a calculus problem before solving it."

Boxplot 1 shows that the data distribution for group B, before its participation in the VC, has more dispersion than group A and it is even more dispersed in Item 2

After applying the U-Test (see chart 1), it is inferred that groups are statistically different regarding the use of a metacognitive strategy (environment control for concentration) and the use of a solving problem strategy in the understanding stage (identification of data before solving a problem). Because of the characteristics of both groups, this difference shows an improvement regarding the mastering of these strategies in the group A.



Passed on 1st attempt Group Before VC

Diagram 1: Comparative boxplot. Group A and Group B. Item 2 and Item 3

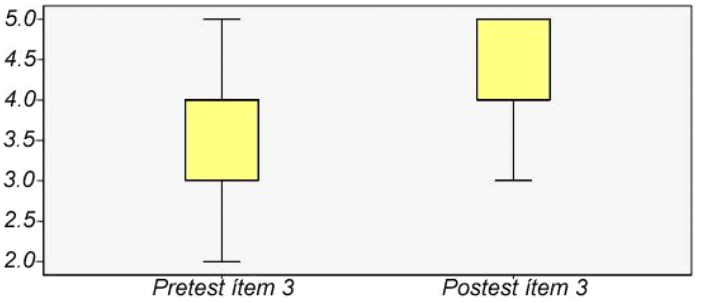


Diagram 2: Comparative Boxplot group B: Pre-test and Post-test

3.2.2 Comparison between the pretest results and the post tests of the group B.

The non-parametric Wilcoxon[14] test was used for dependant or paired samples [15](á=5%). Upon analysis of diagram 2 and interpretation of the results of the statically test used (chart 2), it can be affirmed that students' work in the VC brought about a statistically significant effect on the identifying data modification before solving a Calculus problem. This activity is developed in the "understanding" stage.

Problem-solving was addressed in the VC via different instructional materials, guiding questions of the teacher in each activity, and

Item 3: I identify data in a Calculus problem before solving it

	Post-test Item 3 - Pre-test Item 3
Z	-2.111[a]
Asymptotic Significance (2-tailed)	.035

a. Based on negative ranks.

a. Wilcoxon Signed Ranks Test. Z= standardized variable

Chart 2. Wilcoxon. Item 3. Test Statistics[b]

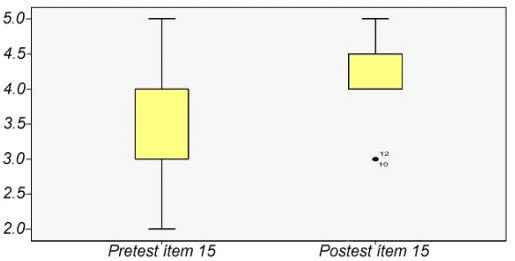


Diagram 3: Comparative Boxplot. Group B Pre-test and Post-test

Item 15: My knowledge about operations on real numbers allows me finding the solution for Calculus problems.

	Post-test Item 15 - Pre-test Item 15
Z	-2.000[a]
Asymptotic Significance (2-tailed)	.046

a. Based on negative ranks. Z= standardized variable

Chart 3. Wilcoxon. Item 15.Test Statistics[b]

homework and activities for the students.

In Diagram 3, data-dispersion decrease is evident whereas it can be affirmed through Chart 3 that there was a statistically significant evolution regarding how knowledge of operations on real numbers allow solutions for Calculus problem. This aspect was constantly enhanced in different moments in the work done on the VC by using different activities.

3.2.3 Comparison between the question paper results of the group A and the post-test of the group B.

The non-parametric Man-Whitney U-Test was used for independent or unpaired samples, (á= 5%), in order to compare group A with group B, after the latter one participated in the VC. Item 2 and 3 were selected for this analysis. In those items, both groups were statically different when compared to the previous one (before group B participation in the VC).

Chart 4 shows that in Item 3 both groups have the same distribution, whereas in Item 2, group B have less data dispersion than in group A. When comparing Chart 1 with Chart 4, therefore, it is evident that there was an evolution in the latter group.

As Chart 4 shows, after using the U-test, it can be affirmed that statistic original differences between both groups disappear after group B participated in the VC.

In sum, results show that there was a statistically significant evolution towards a

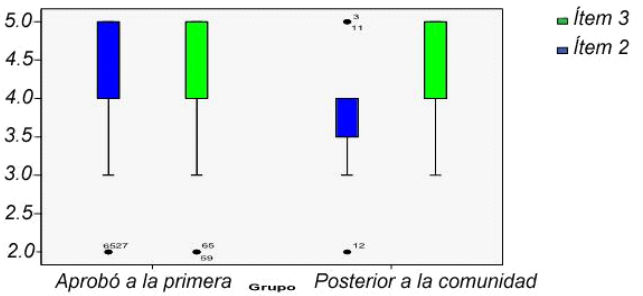


Diagram 4: Comparative Boxplot. Group A and group B. Item 2 and 3

	Item 2	Item 3
Mann-Whitney U	285.000	332.500
Z	-1.206	-.361
Asymptotic Significance (2-tailed)	.228	.718

a. Grouping Variable. Z= standardized variable

Chart 4. U-Test. Items 2 and 3.Test Statistics[a]

more strategic performance of Calculus students after they worked in virtual communities.

4. Discussion.

1. Regarding learning, it can be affirmed that students who approved Calculus on their first attempt (group A) have a more strategic performance than the rest, not only because of the results obtained by using certain strategies, but also because did they not repeat[16] Calculus I. Nevertheless, there are differences in the strategic performance that are evident in the poor or nonexistent mastering of strategies in the acquisition, storage and use of knowledge as well as in the low performance of this group of Calculus II [17] students.

Those results coincide with the results in Camarero, Martin & Herrero (2000)[18]. Additionally, not only are they similar to statements in Roman & Carbonero (2002)[19], but they also confirm what Pozo, Monereo & Castelló (2001, p.254) assert: "It is impossible to make a strategic use of a technique or process that it is beyond your expertise."

2. Based on the studied authors, it is considered that a virtual learning community that encourages the use of strategic learning for Calculus must have the following characteristics: a) it must promote interaction (Garrison & Anderson, 2005) between teachers, students and learning contents through materials and tools provided by an Internet site (virtual class) in which learning can be shared with others, so that meaning can be discussed, ideas consolidated and learning put into practice; b) it must be based on an instructional design that favors community members' developing of high level cognitive and metacognitive processes that let them meet their learning requirements; c) the work in this community must help its members to consolidate their knowledge as well as reflectively plan and assess their actions; and finally, d) the teacher or course tutor must be the main responsible for motivating community members to participate actively, adapting the use of strategies and directing members towards practices that grant knowledge acquisition, and devising learning and evaluation experiences by using cooperative and interactive tech resources that are appropriate for the expected learning goals.

3. To design a VC, four aspects must be carried out: Diagnosing the levels of strategic knowledge of the students who will be participating; defining the content along with the strategies that students are going to learn; selecting a technologic platform; and creating an instructional design which must meet the characteristics previously mentioned. For the application of the virtual class, moderation,

metacognitive, cognitive and social participation must be produced (Del Mastro, 2005; Adrian, 2007) based on the intended instructional design. The experience must be assessed at the end of the VC.

In general terms, on a descriptive level, changes show hints of a more strategically performance among students after finishing their work in the VC. Although it cannot be affirmed that students achieved autonomy in metacognitive and learning strategies, there was a significant evolution regarding the problems solved by the students. This confirms students start to acquire metacognitive strategies since they have minimum expertise in some procedures and they understand some problems which could avoid them repeating the same class again.

Concerning this aspect, the results confirm the conclusions reached by the didactic research group of the Universidad de Sevilla on the subject of using e-learning in the Andalusian universities. As Llorente states (2011, p.33) quoting the results of this research (Cabero, 2010): "the use of the Web has considerable effects on the enhancement of the student performance (more involvement, more participation and activity)".

5. Notes.

[1] The sample probabilistically valid was N=41.

[2] The proficiency average is calculated since a student starts university. It is the quotient between the number of approved courses and the number of registered courses. For instance, a student with a 0.5 proficiency average means that s/he has only approved one out of two courses he has registered for.

[3] The first one for the creation of the design and the didactic organization required to start a Virtual Community. The second one, where the learning process with group members is put into practice, finishes with the achievement of the expected results and the evaluation of the community experience (Adrian, 2007)

[4] It is called: *Question paper on the strategic learning of Calculus of the VC students*. It differs from the question paper of group A because of the reasons exposed

[5]In which it was specified: skills and previous knowledge, learning goals, contents, resources and tools list, bibliographical sources for further study, general orientations, study recommendations, assessment, expected results, and information about course tutors.

[6] Categorical data represent categories or qualities. They are also ordinals when there is order among different categories. (Baron, 2004).

[7] It is a representative chart of the distribution of a data group. To create this chart, five descriptive measures are used: median, first quartile, third quartile, maximum value and minimum value (Peña, 2006).

[8]As little as N=6.

[9] Observations are only required to be independent from each other. (Siegel, 1980).

[10] In all cases, it can be more powerful than the other option, X2 test. (Siegel, 1980).

[11] It was found that the p-value was 0.02 maximum with the exception of Items 7, 14, 20, 21, 22 and 34, which were between 0.05 and 0.097.

[12] Power efficiency of this test is 95.5% when N increases, 95% for medium-sized samples. Therefore, it is an excellent option for the T-test. (Siegel, 1980).

[13] These are samples in which individuals from a group were selected without taking the other one into consideration.

[14] Compared to the T-test, the Wilcoxon test for small samples has about 95% efficiency. (Siegel, 1980).

[15] These are samples in which each subject exerts his/her own control or s/he has a par as similar as it is possible.

[16] This aspect is relevant since, during the two periods, only 89 out of 800 students (11.12%) registered approved the course the first time they studied it.

[17] Only 22 out of 89 students who had passed Calculus I on the first attempt approved Calculus II on the first attempt, that is to say 24.7%.

[18] As stated in Chapter 1, Introduction and bases of the research.

[19] As stated in section 3.1, Part I: Description of group A.

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