RESEARCH ARTICLE

Implementation of Virtual Tools as a Strategy to Improve Teaching/Learning Processes (T/L) in Secondary Education

Implementación de herramientas virtuales como estrategia para mejorar los procesos de enseñanza/aprendizaje (E/A) en la educación media

Implementação de ferramentas virtuais como estratégia para melhorar os processos de ensino / aprendizagem (E / A) no ensino médio

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ABSTRACT

In the last ten years there has been an increase in research on the concept of collaboration. This paper offers outcomes of collaborative learning with mixed methodological approaches and empirical data gained from a We Q-test, guided-interviews, an online-survey as well as case studies. Hence, this paper contributions with a new, innovative We Q-test. In more detail, the We Q-test relates 42 statements, six topics and nine individual factors. The questionnaire asks for the participants' views and how they perceive the views of their team members. The We Q-test evaluates the quality of a team. Regarding the use of the We Q-test in start-ups and NGOs an empirical study was designed. With the findings gained from this research, the project more generally attempts to clarify what learning means with reference to organizational development. By doing so, this research project seeks to contribute to a broader scientific discussion in this interdisciplinary field.

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The authors declare that they have no conflict of interest.

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Resumen

El presente artículo muestra los resultados al realizar la implementación de una metodología *b-Learning* para generar un conocimiento constructivista en los estudiantes que cursaban la asignatura de Física del Colegio Técnico Comfacauca. El proyecto se realizó en tres fases: diagnóstico, desarrollo del EVA e implementación y puesta en marcha del EVA, cada una de estas fases estuvo acompaña de actividades que soportaron la temática elegida y se basaron en la participación activa del estudiante. Los resultados obtenidos muestran que el 53% del grupo experimental alcanza una nota igual o superior a 3.5, mientras que esto ocurre solo con el 39% del grupo control; por ende, se observa un mejor desempeño académico y un grado de satisfacción aceptable hacia el uso espacios virtuales por parte de los estudiantes, lo que permite evidenciar que a través de un modelo *b-Learning* se pueden crear canales asertivos de comunicación e interacción con el estudiante que influyen en su rendimiento académico y generan un proceso de aprendizaje independiente.

Resumo

Nos últimos dez anos, houve um aumento nas pesquisas sobre o conceito de colaboração. Este artigo oferece resultados de aprendizagem colaborativa com abordagens metodológicas mistas e dados empíricos obtidos de um teste WeQ, entrevistas guiadas, uma pesquisa online, bem como estudos de caso. Portanto, este artigo contribui com um novo e inovador teste de WeQ. Em mais detalhes, o teste WeQ relaciona 42 afirmações, sixtopics e nove fatores individuais. O questionário pede as opiniões dos participantes e como eles percebem as opiniões dos membros de sua equipe. O teste WeQ avalia a qualidade de uma equipe. Em relação ao uso do teste WeQ em start-ups e ONGs, foi elaborado um estudo empírico. Com os resultados desta pesquisa, o projeto de forma mais geral tenta esclarecer o que significa aprender com referência ao desenvolvimento organizacional. Com isso, este projeto de pesquisa busca contribuir para uma discussão científica mais ampla neste campo interdisciplinar.

Introduction

The low academic performance of many students in subjects of the Basic Sciences has become a difficulty for many educational institutions that seek to achieve academic excellence. In this sense, the importance of identifying and analyzing to a greater or lesser degree the factors that can influence, are generally considered, socioeconomic factors, the breadth of the study programs, the teaching methodologies used, the difficulty of using a personalized teaching, the previous concepts that students have, as well as their level of formal thought (Sein-Echaluce Lacleta, et al, 2015).

The results of the PISA tests in Colombia for 2018 show that the country performed below the OECD (Organization for Economic Co-operation and Development) average in reading, mathematics, and science. About 50% of Colombian students reached level 2 or higher in science (OECD average 78%) and almost 40% had a low level of achievement in the three subjects (OECD, 2019). Considering the above, it is important to ask about the learning strategies used in the classroom by teachers to address the different subjects that will ultimately allow students to achieve the competencies required by the national education system.

One possibility being worked on in some institutions to reduce low performance has been the inclusion of a series of pedagogical and technological tools aimed at making study schedules more flexible, increasing student achievement rates and guaranteeing completion of secondary education. *Blended-Learning* is one of the most widely used hybrid pedagogical modalities. It combines teaching through traditional face-to-face activities with off-face technology (García, Rosa; et al, 2018). The *b-Learning* brings flexibility to teaching in educational times and spaces, access to multiple resources in addition to those offered by the teacher, new modes of interaction between student-teacher and between students, increase of the autonomy and responsibility of the student in their own process (Salinas, Jesus; et al., 2018).

It is important to highlight that to develop a *b-learning* modality it is necessary to rely on a virtual learning environment (VLE). A virtual learning environment is a space in which different services and tools can be found that allow students to build knowledge through cooperation and interaction with others. (Blanco & Anta, 2016). There are different environments, among which are: platforms of *e-Learning*, *blogs, wikis,* and social networks. The differences between them are based on their technological dimension and the educational potential that each of them offers. One of the most used is *Moodle*, which is a course management system, free distribution, which helps educators to create online learning communities (Pena O., 2018). In the project this platform was used due to its ease to create environments and to navigate them.

In the Colombian education system in recent years, access to education has expanded at all levels and in all areas of the country (OECD, 2016), guaranteeing education for all. However, sometimes the education provided is not of good quality as there are not enough resources. Therefore, an alternative that is being worked on is virtual education; this allows the elimination of barriers to access to knowledge, thanks to the fact that technologies are respectful of diversity, for their ability to adapt to the needs of each person, facilitating access (Medina, 2017).

The topic of Educational Innovation in Colombia is a concern of the National Educational Plan 2014 - 2018 and is being regulated to be a public policy, in the present four-year period, this aspect being an experimental field and that generates a lot of interest. The incursion of ICT in the education sector in Colombia is very incipient and in the department of Cauca is very scarce, evidencing that virtual education is a novel practice and is presented as an aspect to be improved (MEN, 2013).

With the implementation of this research project, the aim is to improve teaching/learning strategies in the subject of Physics for students at the Technical College of Comfacauca through a virtual environment on the platform *Moodle* (technology *b-Learning*) that encourages the desire to continue in the training process and that promotes the creation of more playful and practical spaces for the study of this type of subjects.

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Methodology

The methodology used for this research was experimental and descriptive; we worked with two groups, a control group made up of 56 tenth grade students of the 2016-2017 school year, who were consulted on the grades corresponding to the subject of Physics in period II; and an experimental group with 32 tenth grade students of the 2017-2018 school year, to which different strategies were applied with the aim of improving their performance in this subject.

A three-phase methodology was proposed for the pilot group: Phase I: Diagnosis, Phase II: Development and Phase III: Implementation. In phase 1 (Diagnosis), two activities were carried out. Multiple Intelligence Test based on the theory of Howard Gardner. This test was applied to 32 students and consists of 7 sections that focus their questions on the types of intelligence present in a human being; students had to assign a number from 1 to 4, with 1 absence, 2 low presence, 3 presence and 4 notable presence. At the end this information was encoded, and a score was given for each intelligence. Therefore, it was observed which intelligence predominated in the student (Nadal Vivas, 2015). On the other hand, a Knowledge Test was carried out on 52 students from eleventh grade, where the skills that they must have at the end of the physics course in the tenth grade were evaluated. This test was carried out with the sole purpose of identifying the topics in which the students present most difficulty and focusing the virtual course on these. The test consisted of 40 questions, divided by themes (unit systems, conversions, scientific notation, dimensional analysis, vectors, kinematics, dynamics, work and energy).

For phase 2 (Eva Development), the ADDIE model (Analysis, Design, Development, Implementation and Evaluation) was taken as a reference (Educativa, 2015). The following activities were carried out: Creation of the virtual planner*;* where the objectives (general and specific), bibliographic aids and evaluation for each week are described; Design and methodology of Evaluation*,* to determine the variables that evaluated the course in a quantitative and qualitative way and the Creation of Virtual Objects. All these activities were focused on the topics with greater difficulty than the knowledge test. Three virtual applications were created as well as a space on the *Moodle* platform.

The first application is a game in which the student must overcome some obstacles and when reaching certain points if he answers correctly, he/she can move forward. The questions are of multiple selection type and are focused on the concepts of dynamics and the three laws of *Newton*. Figure 1(a)

The second application is an inclined plane system, in which the student can manipulate some variables such as: angle, mass, initial speed and friction coefficient, can obtain acceleration, normal force and friction force. The drawing of the situation presents the force vectors (Free body diagram), at the end of the simulation, a multiple selection question is presented on the screen. Figure 1(b)

The third simulation is focused on the *Atwood* Machine, where 2 masses are located at the ends of a pulley, and these can be modified to calculate the acceleration and the system tension. In addition, the graph shows the direction of acceleration depending on the value of the masses (movement of the free body system-diagram). At the end of the simulation, students will find 5 multiple-choice questions where abstraction processes and relationship of concepts are evaluated. These allow them to predict the behavior of the system according to certain initial conditions.

Figure 1. Virtual Objects. (a) Game by levels on Newton's Concepts of Dynamics and Newton's Laws. (b) Inclined System.

Source: Own elaboration.

In addition, the Educational Material (videos, presentations and *quiz*) and the EVE Design and Creation were carried out, with resources and assessments, sorting topics by weeks.

In phase 3 (Implementation and start-up of the EVA), training was provided to teachers and students, where the operation of the *Moodle* platform, a learning management system (LMS), was explained. Then the EVA was implemented in the classroom for a month and a half, students could enter at any time of the day, for handing homework in and presenting *quizzes*. At the end, a feedback process was carried out by means of a satisfaction survey to know the students' opinion of this new learning strategy. In addition, academic performance was compared between the control group and the experimental group, and the respective analysis of the results was made with *software R*, which is a free statistical package. This analysis allowed us to identify shortcomings and successes in the strategy that sought to improve academic performance.

Result Analysis

This project aimed to implement the b-*Learning* model in the teaching of the subject of Physics, for the tenth grade of the Comfacauca Technical College, located in the city of Popayán. In the process, *TICs* were used as enriching elements, the Moodle platform, and the combination of strategies of face-to-face education with strategies of virtual education. The analysis of the results focused on the efficiency and effectiveness of the proposed strategy. First, the results of the Psychological Test (multiple intelligence test) were analyzed. In addition, the results of the knowledge test in the subject of Physics were considered in order to identify the topics of greatest difficulty. For the effectiveness of the course, academic performance and overall quality of the course were considered and for efficiency, the results of the satisfaction surveys and the expectations aroused in the students were considered. It is important to highlight that the b-*Learning* model allows the active participation of the student as long as the teacher designs pedagogical strategies that allow supporting, informing, communicating and interacting since it can generate in the student specific knowledge of the subject and promote in them the development of strategies for autonomous learning. (Rodriguez, Oswaldo, et al, 2010)

Psychological Test of Multiple Intelligences

Below are the student averages for each of the multiple intelligences assessed by the test. As can be seen in *Table 1*, students perceived their strengths in interpersonal and intrapersonal intelligence and their weaknesses in Mathematical and Linguistic Logic. This is evidenced in the coefficient of variation where linguistic intelligence presents less dispersion around the average; therefore, it is observed that students have marked deficiencies in this type of intelligence.

Table 1. Measures of centralization and dispersion of intelligence types.

Intelligence	mean	sd	Cv
Space Intelligence	5,859,375	8.820.282	0.1505328
Physical Intelligence and	5,518,750	10.470.966	0.1897344
Interpersonal	6.125.000	8.736.280	0.1426331
Intrapersonal	6.250.000	8.107.145	0.1297143
Linguistic Intelligence	5,478,125	7.005.686	0.1278847
Logical Intelligence Mathematics	5,186,563	9.749.627	0.1879786
Musical Intelligence	5,523,438	14,623,768	0.2647584

Source: Own elaboration

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It is important to note that students who prefer debate are possibly those who have well-developed conventional intelligences (verbal-linguistic and logical-mathematical) and social (interpersonal and intrapersonal). On the contrary, students who prefer to work through simulation are probably the most physically active (body-kinesthetic), articulate well (verbal) and are sociable (interpersonal and intrapersonal). Therefore, the virtual course focused on teaching based on discussion and debate (forums, chats) since this can help them develop their conventional intelligences (verbal and mathematical) and social (interpersonal and intrapersonal); and at the same time through the virtual objects created (games, simulations, *quiz*) favor the other intelligences. In each week of the course the student found the concepts described through mental maps and images, also simulations where the student interacted with the variables that described a phenomenon and at the end some questions were asked that allowed him to develop abstraction and analysis skills. In addition, they found chats and forums where they could share experiences or doubts, and the teacher and colleagues could provide feedback. All this was done in order to work most of the intelligences through the different activities proposed.

Knowledge Test

In *Table 2* students' performance by subject can be observed. The topics with the highest number of errors were Work-energy, Dynamics and Kinematics with inaccuracies of 51.05%, 55.45% and 69.87% respectively. It was intended to work on all of them using the virtual course, but due to the difference in academic calendar between the school and the research project of the University it was not possible to address the Energy-work theme, which presented a higher rate of inaccuracies. Therefore, the decision was made to implement the strategy with the second theme with lower performance.

Table 2. Performance in subjects in the Physics knowledge test

	No of questions	Density of no hits	Percent of errors
Unit systems	3	0,18	17,95
Units conversion	3	0,07	7,05
Dimensional analysis	3	0,22	22,44
Scientific Notation	2	0,17	17,31
Vectors	6	0,32	31,73
Kinematics	11	0,51	51,05
Dynamics	6	0,55	55,45
Energy - Work	6	0,7	69,87

Source: Own elaboration

In the Dynamics section, the questions with the highest number of errors, about 71%, were in problem solving processes that involved the application of the three laws of *Newton*, therefore, the virtual objects that were designed for the course sought to strengthen the competencies of these processes.

Academic performance

Academic achievement results are shown in *Table 3*. The first column corresponds to the course modality, the following is the average, standard deviation, and coefficient of

variation. Table 3. Grades obtained in the subject of Physics

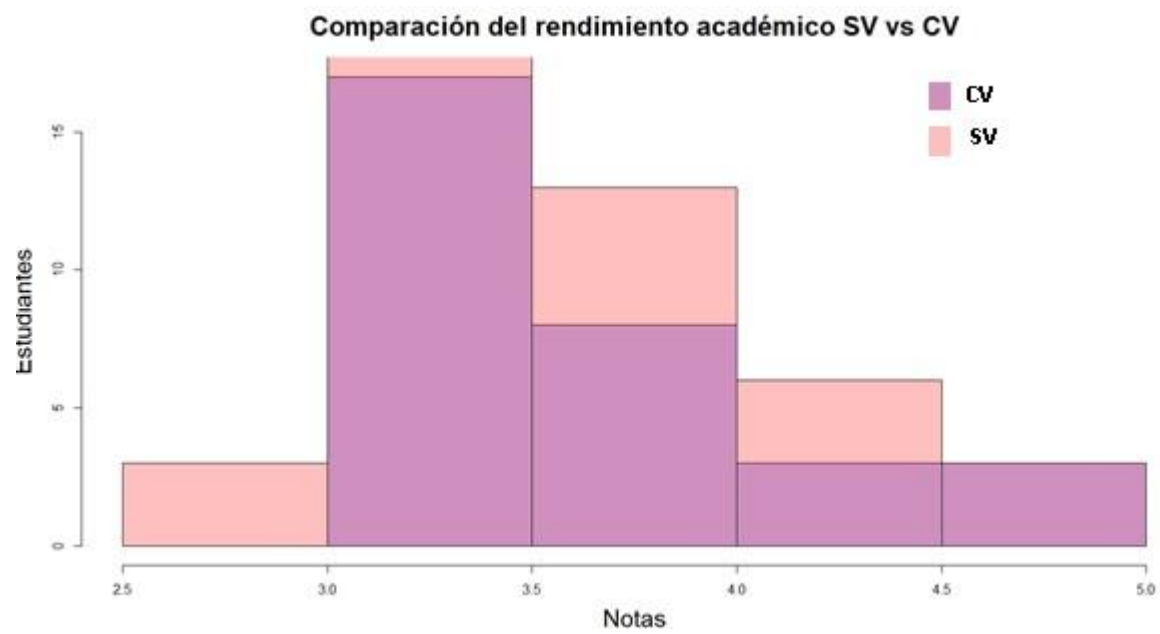
Course modality	Mean	sd	C.V.
With virtualization	3.661	0.672	0.18
Course without virtualization	3.564	0.825	0.23

Source: Own elaboration

As can be seen in Table 3, the coefficient of variation with the *virtualization modality* is less than *without virtualization*, this indicates that there is less dispersion of the data (grades) with respect to the average. In addition, an improvement in the performance of the subject with respect to the control group is observed, due to the strategies used, which were based on a b-*Learning* methodology.

Considering that the subject is passed with 3.0 marks, the control group (SV) obtains an average above this value, although some students failed to pass the subject, while the experimental group (CV) obtains an average above the control group and there are no students who lose the subject. In addition, some reached grades greater than 4.5. *See Figure 2* .

Figure 2. Comparison of the academic performance of the subject according to the modality used.



Source: Own elaboration

Figure 3. Box Plot on the comparison of the academic performance of the subject according to the modality used

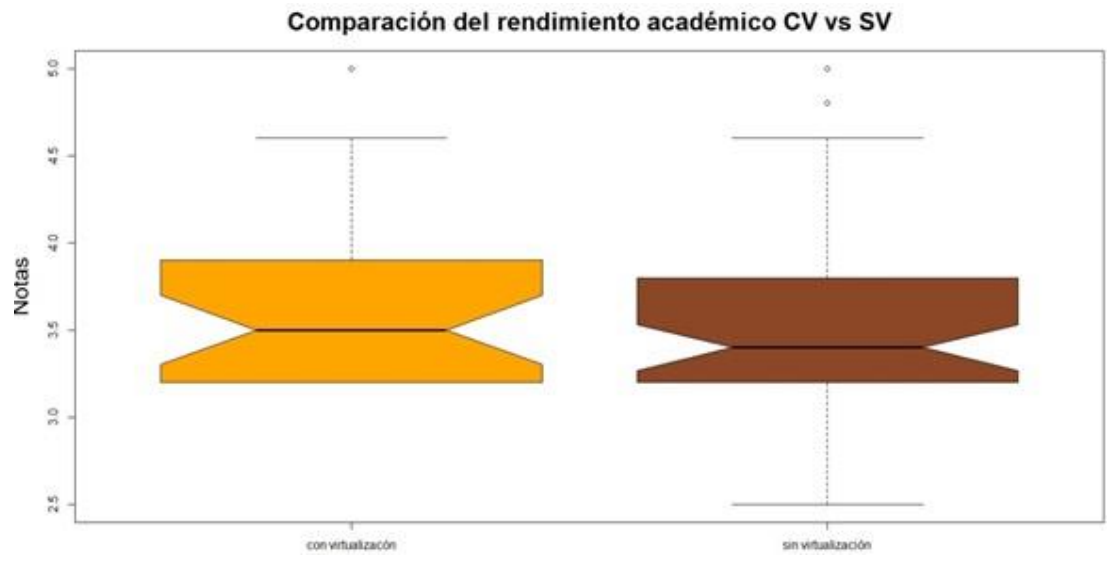


Figure 3 shows that in the box plot of the CV course. The median is located almost in the center of the diagram, while in the SV course it is located towards the bottom of the diagram, indicating a greater dispersion of the data.

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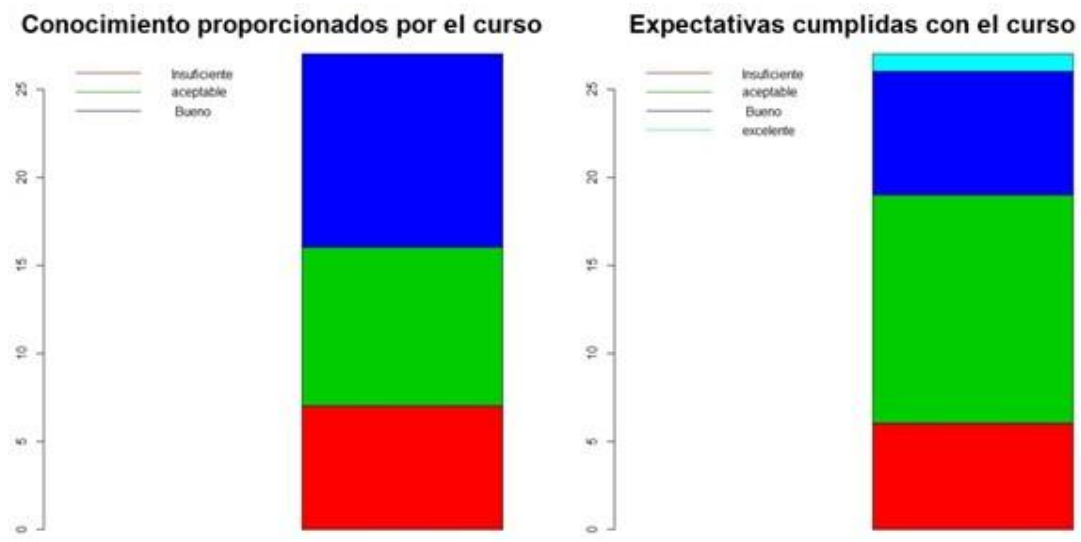
The results obtained allow us to affirm that the students who participated in our experience have acquired greater competences thanks to the training strategies supported in the b-Learning modality. It can be concluded that the experimental group obtained scores above the control group and also some with scores above 4.5. Therefore, the learning supported with the Moodle platform allowed the student to improve his learning process and this is reflected in the scores obtained.

Satisfaction assessment:

To determine the degree of student satisfaction regarding the materials, teachers and different quantitative and qualitative aspects of the learning process, a survey was carried out at the end of the virtual course. In this way, students could express their general opinion on the methodology used, 27 students who used the methodology discussed above decided to answer the survey voluntarily and freely. The survey consisted of consulting the opinion on five different aspects: (a) General information of the course; b) About the teacher; c) About the activities and contents; d) About the evaluation and e) Satisfaction and usefulness of what has been learned.

With regard to the satisfaction and usefulness of what was learned, it was identified that although initially the students came with low expectations of the new training model, subsequently these were modified towards more positive values; about 70% considered that they acquired new knowledge and their expectations were reached at a good and acceptable level. Thanks to the interactivity of the system, learning is more effective and exerts a motivating influence on the student; some activities such as videos allow the student to retake the concepts seen in class through the solution of problems, in addition the activities focus on generating an independence that allows working at the pace of each one. See Figure 4 .

Figure 4. Results of the Satisfaction Survey section "Satisfaction and usefulness of what has been learned"



The students positively valued the experience and novelty of the strategy because it allowed them to learn in an alternative way to the traditional one and this can be useful in the future when they are in the University.

Conclusions

Through the results of the satisfaction survey, students consider that virtual platforms can be a very useful tool to promote and reinforce the teaching-learning processes outside the classroom; for them it was easy, from a technical point of view, the work with *Moodle* and the general opinion on the experience, according to the survey has been very positive, 41% of them considered it good and 22% acceptable, indicating that

the work on the platform has helped them a lot in their learning. The evaluation tests have facilitated the continuous monitoring of their performance throughout the experience. The structure of the virtual course and the learning resources had a positive impact on the use of the platform and on the study methods of the students. In addition, they strengthened the understanding of the contents, the academic performance, and the ability to learn autonomously; these strategies allow the development of generic skills such as collaborative work, the critical search for information, self-learning and the use of ICT.

Finally, a comparative study of the academic performance of students has been made using a b-*Learning* methodology and a traditional methodology in which it is shown how the insertions of ICT allow to improve the learning system. This was reflected in the average of the CV course, which was above the average of the SV course. it is important to note that in the CV course some students obtained grades above 4.5 and none failed the subject.

Finally, students value more positive than negative aspects and the possibility of creating these spaces for other subjects could be raised; therefore, the possibility of applying the strategy of *Bleanded-Learning* with the students of the Comfacauca University Corporation in the different subjects of the Department of Basic Sciences is raised, because in these there is a low performance and high desertion by the students.

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