Digital educational strategies to support basic engineering science courses

Estrategias educativas digitales como apoyo a cursos de ciencias básicas de ingeniería

http://dx.doi.org/10.18381/Ap.v9n1.1983

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Keywords
Virtual learning environments; engineering; failure rates

ABSTRACT

In this paper there are described some educational strategies based on virtual learning environments, which were implemented in engineering programs with the purpose of mitigating failure rates in basic stage subjects. Based on a case study at the University of Baja California, the causes of failure for the period 2013 to 2016 were diagnosed, and subsequently, from 2017 to 2019, the implementation of four support strategies began. An analysis of the behavior of the failure rates before and after the implementation of the strategies was made, and the results show up that both the failure levels in five subjects as well as the student lag decreased. Even though the strategies applied in this study are replicable, and the use of virtual learning environments supports students' academic performance, it is still necessary to expand the research to measure the impact of additional strategies that were implemented simultaneously.

Palabras clave
Entornos virtuales de aprendizaje; ingeniería; índice de reprobación.

RESUMEN

En este artículo analizamos las intervenciones de diferentes estudiantes en el capítulo de tesis de un par y en el propio capítulo en las actividades de retroalimentación de pares y expertos propuestas en un taller virtual de escritura de tesis. Se seleccionaron casos de alumnos que formaron parte de grupos de trabajo de dos estudiantes y un docente de un seminario virtual de 90 horas orientado a la enseñanza de la escritura de la tesis, que se realizó en 2017 en la Universidad Nacional de Cuyo. La propuesta ha sido que cada alumno, junto con el docente, analice el propio capítulo y el de un par teniendo en cuenta tres fases: primero, trabajar con el modelo de situación comunicativa y el modelo del evento; segundo, con el modelo textual, en particular con los movimientos y pasos; tercero, también con el modelo textual, pero las estrategias lingüísticas. En estas fases se promueven dos modalidades de retroalimentación: en texto y global. Ambas se analizan considerando: encadenamiento, foco, función y tipo de análisis. Los resultados muestran diferencias con significatividad estadística en los comentarios al capítulo del par y al propio según la modalidad de retroalimentación, así como de estas modalidades entre sí.

Received: September 30, 2020
Accepted: February 22, 2021
Online Published: March 26, 2021

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INTRODUCTION

The importance acquired by information and communication technologies (ICT) in today's world, and the evident preference of students on the use of these tools, turn ICT into a feasible alternative for the implementation of learning strategies different from the traditional ones, attractive and practical to attract the attention of digital native students, that their motivation be improved and that they help them in their learning process (Lozano Zarate & Llaven, 2018). In the current knowledge and digital age, there is access to information on the web everywhere and any time; however, since it is not always possible to assure the quality of the resources inquired, it is necessary that students have guidelines to help them find the best way to build their own knowledge (Chang, 2015). In this sense, the range of content may be useful when they are prepared to tell the difference between reliable and misleading content, but if they lack this preparation, exposure to this massive information may be counterproductive (Canto & Salazar, 2019).

ICT may be great allies for students to manage and build knowledge, and to favor their academic results (Morales, Trujillo & Raso, 2015) if their intervention in an instructional design is planned (Vazquez, Vite & Contreras, 2013). An example of this is Virtual Learning Environments (VLE), IT applications to create academic and pedagogic communication among participants, and that may be used both in the classroom environment and in distance or mixed modes (Cedeño & Murillo, 2019). VLE are a means to share information, to support communication and integration of different types of digital resources, and to facilitate the learning process (Romero *et al.*, 2014). In accordance with Pastran, Olivera & Cervantes (2020), their use improves teaching, as they allow teachers to accompany their students during their learning process, especially in distance education.

Educational results are a basic part of VLE, because their availability and range of formats offer the possibility of improving the quality of remote or traditional teaching courses (Valenzuela, Fragoso, Santaolaya & Muñoz, 2017). Another element of great importance in the context of VLE are digital repositories (DR), which operate as containers or repositories of digital resources –such as instruction materials, reports, publications, courses, manuals and learning objects (Shreeves & Cragin, 2008)– and encourage preservation and reuse of these contents (Bote & Minguillon, 2012).

For this reason, some educational institutions develop their own digital educational resources –such as VLE– to address different topics of the learning units included in their syllabi; this, in addition, responds to the actual need to share knowledge with facility of access and availability (Colome, 2019). Implementing VLE may also benefic academic performance, which took place at the Faculty of Engineering (FE) of the Autonomous University of Baja California. This academic unit, as well as

others of the university, face problems associated to academic achievement of common core students, a basic stage with a period of two semesters, comprised by twelve compulsory learning units in the areas of mathematics, physics, chemistry, humanities and programming. When students enroll the FE, they take a common core and when they complete it, they go through an auction process where their current average is considered to earn a place in the educational program of their preference.

A statistical analysis of failure indexes of the learning units offered in the common core showed that some units maintain failure indexes over 40% for the semester starting in the month of August, and 60% in the term starting in February. This is an alarming situation, because between four and six students of ten have learning difficulties, which usually leads to school dropout. For this reason, the urgency of redoubling efforts and increasing supporting mechanisms for students, that would allow them to improve their academic performance and their grades, and to advance towards the following stages of their bachelor studies, aimed to prevent that they are stuck in the basic stage.

In spite that VLE are not the topic for emerging research, the needs of the FE have led to adopt better documented practices in this field. The results of implemented strategies are presented in this work, from the use of the VLE since 2017, aimed to improve academic achievement of students in the basic stage, as well as developments to date.

METHODOLOGY

Study methodology was divided into three stages: the first one consisted of a diagnosis of the academic situation of the learning units in the common core, with the intention of identifying those with the greater failure index from 2004 to 2016; in the second stage, four supporting strategies were implemented based on the VLE, from 2019 to date, with the purpose of offering students of these subjects with a high failure rate with additional mechanisms to strengthen knowledge appropriation required by these subjects. The strategies were as follows:

- Developing two remedial courses: 1) fundamentals of mathematics and 2) functions and derivatives.
- Homologation to conduct courses supported by the institutional and educational Blackboard Ultra platform.
- Implementing repositories of digital educational resources to deliver materials of learning units.
- Developing educational videos. For this purpose, teachers were recorded teaching their lessons, and their videos were published in the YouTube channel of Digital and Didactic Resources of the FME.

Finally, in the third stage of the methodology, the impact of implemented strategies was appraised, by means of a statistical analysis of passing indexes of the learning units identified in the first stage of the study, from 2017 to 2020.

Academic diagnosis of the common core

Every year there are statistical data on the academic results obtained for each of the learning units of the FE. They are reviewed at meetings with professors in order to define strategies that would allow them to be improved and increase the quality of education. Thanks to these statistics, learning units of Differential Calculus, Integral Calculus, Linear Algebra, Statics, Electricity and Magnetism, and Programming were identified as subjects with the largest failure index of the common core and, therefore, they are subjects upon which efforts are to be redoubled with the purpose of increasing passing indexes.

An analysis was done in 2017 on passing, failure and school dropout percentages of the common core obtained in previous years (Turrubiates, Herrera & Martinez, 2017). It showed that in 2016-2, there was a student population increase which, among other factors, was due to educational lagging in the learning units mentioned above.

Chart 1 shows that from semester 2004-2 to 2008-1 there is growth stage in the number of students enrolled in the common core, and that required of an approximate period of four years for the population to be established. From the 20147-2 semester, there was an increase of the total common core population to reach 1,828 students in the 2016-2 semester (Turrubiates, Herrera & Martinez, 2017).

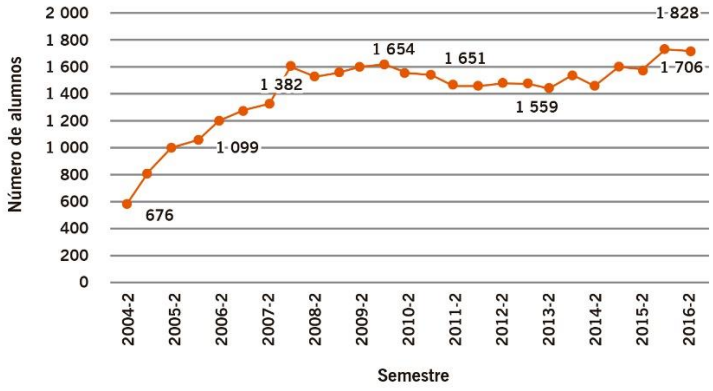

Chart I. Common core population from the beginning to the 2016-2 semester.
Source: Turrubiartes, Herrera y Martínez (2017).

It is important to mention that the educational term of the University of Baja California is divided into two periods: the first one, called *uneven*,

begins in the month of February and ends in the month of June, and the second, called *even*, starts in the month of August and ends in the month of December. In the even term, students enrolled who obtained the higher results in the university placement test, and the remainder enrolled in the uneven term. The learning units of the subjects of Differential Calculus and Linear Algebra were taught in the first semester, and as may be seen in table 1, in the uneven terms, the failure index is way above 50%, whereas in the even term, it is below. Conversely, this is the case of the learning units of Programming, Statics and Electricity and Magnetism, taught in the second semester, whose greater failure percentage is in the even term (see table 1).

Table 1. Failure percentages in learning units of study

School period	Diferential calculus	Integral calculus	Linear algebra	Programation	Static	Electricity and magnetism
2013-1	65.5	39.05	50.31	33.53	31.64	29.18
2013-2	40.33	50.55	23.60	48.7	43.34	40.61
2014-1	68.53	42.56	54.85	32.22	36.5	25.26
2014-2	39.77	47.99	23.05	46.67	40.38	37.61
2015-1	61.57	42.7	54.00	33.66	28.8	21.73
2015-2	33.48	46.55	23.86	41.28	39.66	38.7
2016-1	61.60	42.29	47.32	32.94	31.18	20.29
2016-2	30.82	46.74	20.84	38.42	30.08	33.48

In addition to reviewing results per learning unit, we thought it was relevant for the study that the results obtained by professors who teach these units were analyzed. In view of the size of the student population in the common core, there are 20 groups allocated among different teachers per each subject. From our observation it was found that there are teachers who, throughout the years maintain student failure indexes above 60%,

whereas there are other professors whose indexes are below 20%, and the remainder stays in a mean of 40% of failed students. This variation of results led to find out with teachers what the reasons were, and the main ones were identified to be the different complexity levels of partial tests, excess or lack of activities done in the course and dissimilar evaluation criteria.

IMPLEMENTATION OF STRATEGIES

Levelling courses of Mathematics: Mathematical fundamentals/Functions and derivatives

New students of the FE attend a propaedeutic course for one week seeking to level the knowledge students acquired during their instruction in high school to the knowledge required to enroll the university –topics of mathematics are generally seen. At the end of the course, the students sit a test and, as a function of their score, they are assigned their class schedule. This test is passed only by 20% of the population, which means that first semester students enter without the necessary bases for a good performance in the courses of Differential Calculus and Linear Algebra.

With the purpose of reducing this problem and as an effort to ensure that students have the minimum necessary knowledge in mathematics, the course of Mathematical Fundamentals was designed as an additional course for first semester students who did not pass the propaedeutic course, who are asked to take it for the first six weeks of classes, at the same time they take the rest of their subjects. Likewise, this course is taken by students who are repeating the subject of Differential Calculus, for they are asked to take it and that their bases be improved.

In Solis, Justo, Herrera, Martinez & Turrubiates (2019) the course of Mathematical Fundamentals is described as a self-managed course, taught online for free, designed by following a gamified strategy –that incorporates game elements as a series of rules, the use of points, the obtainment of insignia by means of achievements, leaders' boards, mathematical challenge and defiance, an unlimited number of attempts and rewards– where there is feedback. This course is available at the institutional platform of the Blackboard Ultra University, and with the purpose of inspiring students to finish it, this course is given a value of 10% in the score of the first partial test of the Differential Calculus subject.

At the FE, assessing the learning units mentioned in this study is done as follows: 30% of the final course score is for a departmental test and 70% of the remaining score is from partial tests, tasks and participation done during the period, which are assessed at the closing of the academic term. In the case of the Differential Calculus subject, in average, only 23% of students pass the departmental test, while 50% manage to pass the subject with the minimum passing score, which is 60. In view that the subject is a series of Integral Calculus, which is taught in the second semester, has

been the source of concern for students to take this subject without having shown sufficient competency in the departmental test of the precedent subject.

For this reason, in 2018-1, the Functions and Derivatives course was implemented, aimed for students who take Integral Calculus in the second semester and who failed the departmental test of Differential Calculus of the first semester, but who passed to second semester. Like the Mathematical Fundaments course, the students ought to take it during the first six weeks of classes, at the same time as the rest of the subjects, it is taught online and available at Blackboard Ultra; in addition, it is self-managed, free and with several didactic resources and assessments which the students are to pass to obtain a score of 10% in their first Integral Calculus partial test. It must be stated that, different from the Mathematical Fundamentals course, Functions and Derivatives was not designed with the gamification strategy.

Standardization on how to teach courses: The Blackboard Ultra institutional platform

As mentioned in the previous section, Blackboard Ultra is the institutional platform which the University of Baja California uses to lodge courses taught under the distance or part-time attendance modes. Under a school work, teachers of the different learning units engaged in the task of developing instructional designs for the learning units studied in this research, that would serve as a guide for teaching courses in the classroom attendance mode, where the platform served as a support for the allocation of digital didactic material, testing, and delivery of weekly activities.

The strategy sought that the platform served as a mechanism to standardize the manner in which teachers teach their courses, in a way to respect free professorship and to guarantee that all of the students have access to the same information and inquiry sources. Furthermore, as part of the schooled work, item banks were done for partial testing, whereby it was assured that the complexity thereof was in accordance with the competencies which the student is to attain according to each learning unit.

Repository of digital education resources

The university provides students and teachers access to Google applications by means of institutional email accounts. With the purpose of taking advantage of this using the Google Sites platform is allowed, spaces were created for each learning unit, for publication of educational resources organized per thematic units, topics and subtopics. Thus, a student has a space permanently lodging revised educational material and selected by teachers, appropriate for learning mathematics, physics, and programming. Among the materials, they can find resources developed by

teachers of the university and others selected from external sources, with due recognition of copyrights.

Educational videos

Upon consideration of the taste and interest of students to watch all kinds of videos, a decision was made to generate educational videos intended to support the teaching-learning strategies of teachers. In 2019, seven teachers recorded their lessons (made a total of eleven videos), and three students who give advice on Integral Calculus, Programming and Chemistry recorded a vide each; they are available in YouTube Didactic Digital Resources of the Faculty of Mechanical Engineering, which is part of a research project seeking to create a digital repository of didactic material for engineering (in English and Spanish), to help in enriching the teaching-learning processes in different study modes, at the same time enabling preservation and conveyance of experience and knowledge, both of teachers who work there and consulting students. This conveyance of knowledge, Standard ISO-9001:2015, clause 7, is called "knowledge of the organization", and enables preservation of teaching experience and keeps it available to strengthen the generation of new knowledge and ensure the quality of the educational process (ISO, 2015).

At the same time, a rubric was designed where the elements to be considered in the development of educational videos are established to assure their quality with regards to format and content. This rubric contains identification data, an assessment section and one on the pedagogic design (Robles, Justo, Mariscal & Cardenas, 2020). In the assessment section design and audiovisual production are considered, such as quality of image and sound, that written text is germane to orthography and grammar rules, as well as the relationship between images, text and narrative; in addition to aspects related to the presentation of data within the video that contain the name of the university and the faculty, institutional logos, credits and theme.

On the other hand, in the pedagogic design section, accuracy and updated information presented are revised, such as the logic sequence of the approached content, identification of key concepts, the use of supporting resources (charts, illustrations or examples), clarity and adaptation of language and use of colors and typography. It must be noted that all the videos developed, at present, meet the recommendations of the rubric.

RESULTS

In the presentation of results for the behavior analysis on passing indexes of learning units of the 2013 2019 period, a variation of numbers is noted

before and after the implementation of strategies. Furthermore, the results on the implementation of the courses of Mathematical Fundaments and Functions and Derivatives are described accurately, as well as the results of passing indexes observed in the subjects upon which the strategies were implemented.

Chart 2 shows that the population in the common core had the highest number of students in the 2017-1 period (1,824 students), and from that point, it decreased gradually until the mark of 1,601 students in 2019-2. The dropout index in the common core in the 2013-1 to 2019-2 period is presented in chart 3, where both the percentages per semester and the trend (red line) show that the index has had a significant reduction, and remains down as of the 2017-1 period, which is among those who have reported the highest dropout indexes (above 50%). Notwithstanding, desertion is low: reaching a level below 30% in 2019-1, since implementation of strategies began in this period.

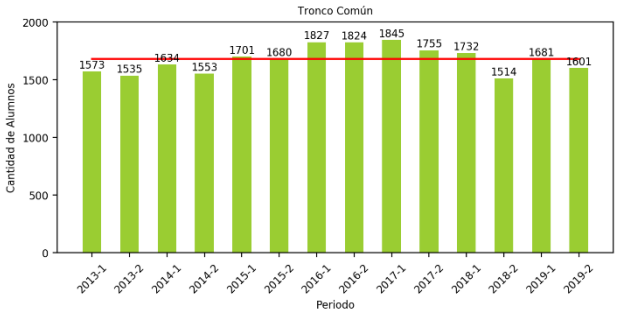

Chart 2. Behavior of student population in the common core.
Source: from Balbuena (2020).

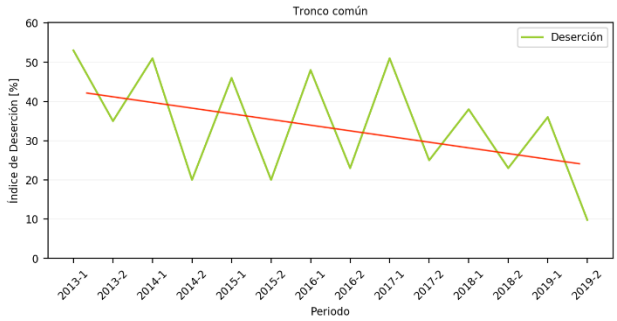

Chart 3. Dropout index in the common core.
Source: from Balbuena (2020).

Mathematical Fundaments Course

As part of the strategies implemented, Mathematical Fundaments was offered for the first time in the 2017-2 and 2018-1 periods as an elective

course for students, under the teacher's recommendation to take it to reinforce important mathematical basis for the subject of Differential Calculus. Chart 2 show that the percentage of students in these periods who pass the course is less than the percentages obtained as of 2018-2, this is due to the fact that from this period, attendance to the course was assigned a value of 10% of the score of the first partial test of Differential Calculus, which is reflected in the number of students who passed the course.

The impact of the course of Mathematical Fundaments is assessed as a function of the number of students who passed it and who, in turn, passed the learning unit of Differential Calculus. Chart 2 lists the percentages of the course impact from 2017-2 to 2019-2.

Table 2. Mathematical Foundations course results

Period	Students enrolled in the virtual course	Students who accredited the virtual course	Students who approved the subject Differential Calculus
2017-2	430	307 (71.39%)	223 (72.64%)
2018-1	610	223 (36.56%)	174 (78.02%)
2018-2	626	554 (88.46%)	309 (55.78%)
2019-1	642	436 (67.91%)	104 (23.85%)
2019-2	582	513 (88.14%)	344 (67.06%)

Source: prepared with information from Solís *et al.* (2019).

Functions and Derivatives Course

Chart 3 shows the percentage of the impact of the Functions and Derivatives from 2018-1 to 2019-2, where the number of students who passed the virtual course and who, at the same time, passed Integral Calculus. In the results, it may be seen that in the 2018-1 and 2018-2 periods, the number of enrolled students is less than in 2019; this is due to the fact that in 2018, the course was offered as an elective course, while in 2019, attendance to this course was considered to be 10% of the score of the first partial test of Integral Calculus.

Table 3. Course Results Functions and Derivatives

Period	Students enrolled in the virtual course	Students who accredited the virtual course	Students who approved the subject Comprehensive Calculus
2018-1	81	16 (19.75%)	10 (62.5%)
2018-2	96	22 (22.92%)	12 (54.55%)
2019-1	193	10 (51.81%)	26 (26%)
2019-2	223	98 (43.95%)	37 (37.76%)

Results per learning unit

The values in chart 4 show that, generally, the learning unit of Differential Calculus has a reduction of the failure index both in the odd (blue line) and the even (orange line) period. In 2016-1 this percentage was 60% and in 2019-1 it decreased to 56%. Regarding the even period, in 2016-2, the failure index was 30% and it reached a minimum value of 14% in 2019-2. It must be clarified that in 2019-2 the FE started a new syllabus, which brought about the reconstruction of the subject. This decreased the failure index from this period, as there were no lagging students taking the subject, there only were new students.

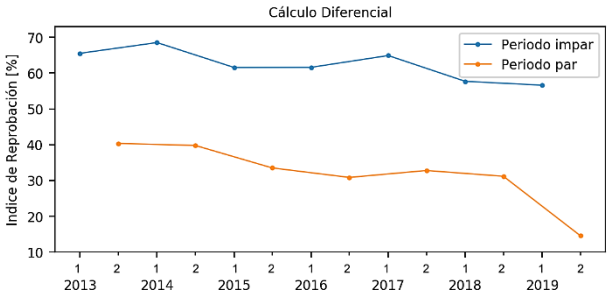

Chart 4. Failure index of Differential Calculus.
Source: adapted from Balbuena (2020).

The failure index for the learning unit of Integral Calculus also has a reduction in both periods (see chart 5). In 2016-1, before the

implementation of strategies started, the index was 42% and, after that, in 2019-1 it was 35%. In the case of even periods (orange line), in 2016, the failure index was 47%, and as the strategies were applied, there was a clear reduction, which, for 2019 it is expressed in 27%.

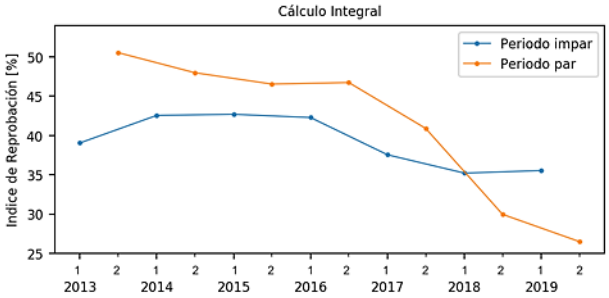

Chart 5. Failure index of Integral Calculus.
Source: adapted from Balbuena (2020).

In contrast to the two previous learning units, the failure index of Linear Algebra only had a slight reduction in the odd period (see chart 6, blue line); however, the index still is around 45%. Along with the above, there is a slight increase in the even period, whose highest value (26%) is shown in the 2018-2 period. This is the only one learning unit with an increase in the failure index. Notwithstanding, it must be noted that the new syllabus brought about restructuration of the subject, which in the 2019-2 period was offered as Superior Algebra, and which, as it is a new subject, did not begin with lagging students and their failure index was 15%.

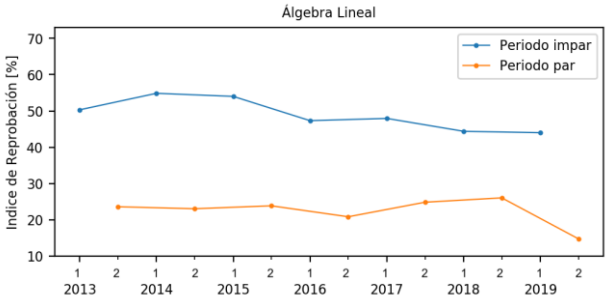

Chart 6. Failure index of Linear Algebra.
Source: adapted from Balbuena (2020).

On the other hand, the learning unit of Programming has a greater reduction in the Failure index of the even period (see chart 7). In contrast, in the odd period, there was a significant reduction in the 2017-1 and 2018-1 periods, but it increased again in 2019-1. In 2016-1, the index was around 33%, and for 2019-1 it was 31.85%; while in 2016-2 the failure index was 38.42% and for 2019-2 it was 35.7%.

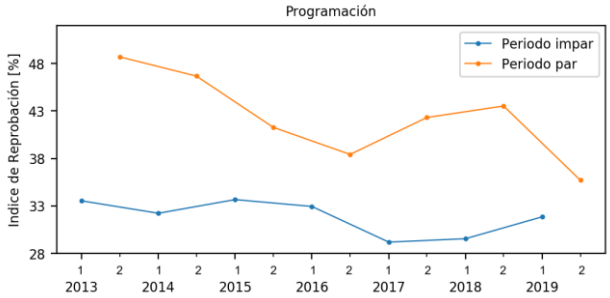

Chart 7. Failure index of Programming.
Source: adapted from Balbuena (2020).

The learning unit of Statics show a failure index decrease both in the even period and the odd period (see chart 8). In 2016-1, the failure index was 31% and for 2019-1 it went down to 25%. In the case of even periods (orange line), in 2016-2, the failure index was 30% while for 2019-2, the index decreased to 26%.

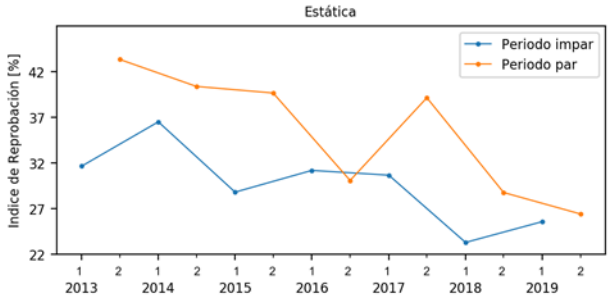

Chart 8. Failure Index of Statics.
Source: adapted from Balbuena (2020).

Electricity and Magnetism shows a greater reduction of the Failure index of the even period (see chart 9, orange line); in 2016-2, the failure index was 33.48% while for 2019-2 the index was in 22.97%. This reduction, although lesser, also occurred in the odd periods; of a failure percentage of 20.29% in 2016-1. For 2019-1, it was 19.81%.

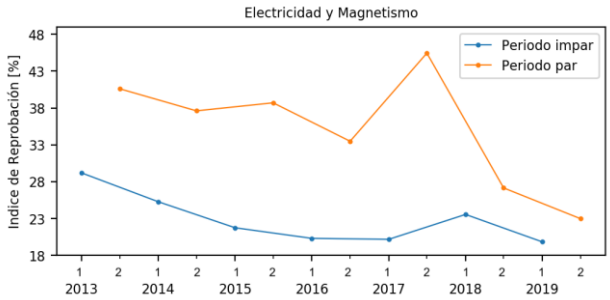

Chart 9. Failure index of Electricity and Magnetism.
Source: adapted from Balbuena (2020).

DISCUSSIONS

There are several factors intervening in the teaching-learning process that limit the benefits which the use of technologies may offer, such as prior experiences of students to manage technology, for or without educational purposes (Ramirez, Urith & Barragan, 2018), and the multiple factors involved in the students' academic performance, such as psycho-emotional factors, no considered in this study (Vera, Ramos, Sotelo, Echeverria, Serrano & Vales, 2012). In this study case of the FE, it is considered that as of 2017, passing statistics have shown significant improvements, which allows us to conclude that implemented educational strategies based on VLE have had a positive influence on students and on their performance.

In the period between 2016-1 and 2017-1, student population in the common core have reached their peak, but as of 2017-2 there was a reduction of the number of enrolled students (Balbuena, 2020). This is due to the improvement of passing percentages of the learning units, since the number of students entering each semester is stable. Moreover, dropouts have decreased considerably, which shows that the reduction of the population is not due to the fact that students are dropping their studies. In accordance to results, the impact of the course of Mathematical Fundaments is more positive that the course of Functions and Derivatives; it is believed that this is due to, on the one hand, the gamification strategy followed in the design thereof (Pascuas, Vargas & Muñoz, 2017), and on the other, to the fact that students who take it are new students, and would have a more intense motivation because of their recent enrollment in the university (Fernandez, Mijares & Alvarez, 2013).

Integrating ICT in designing courses in the mathematics area for engineers improves student training, and it is mostly significant when they are present in the assessment (Cabrera & Vitale, 2019). Some works show that formal implementation of VLE, and especially of digital repositories, make students feel confident that they are consulting validated resources,

approved by their institution, which may be of help in their instruction and that, furthermore, favor their motivation, with which a better academic performance is attained of the learning units, where they will have access to these resources (Pacheco, Lopez & Andrade, 2015; Cabrera & Vitale, 2019).

Standardization of how courses are conducted by means of the Blackboard Ultra platform implied, as proposed by Sampson, Zervas & Sotiriou (2011a), that teachers shared with their colleagues teaching experiences that have trained them as renowned professors at the institution; this interaction, later consisted of the preparation of an instructional design that would enable agreements in the assessment of the diverse activities which the students do by means of this platform (Sampson, Zervas & Sotiriou, 2011b). nonetheless, it was not easy that teachers adopted this way of work, because, when universities implement new learning technologies, teachers do not adopt them so easily as expected (Liu, 2020). The purpose of this standardization strategy was that of dissolving differences between the passing indexes each professor keeps in his groups, but even when there were improvements, a further study is required to analyze how this strategy has had an influence on the results.

Regarding the use of educational videos, it is concluded that they support both practical and theoretical topics, since, in addition to conceptualizing, they also explain the performance of the laboratory practice by means of proving experiments in the physics, chemistry and programming areas. There are studies that show that using educational videos as a didactic material improves students' grades (Rodriguez & Fernandez, 2017); Perez & Cuecuecha, 2019), when videos are combined with collaborative learning, they become an efficient means for learning (Liao, Chen & Shih, 2019). Videos are a source for the conveyance of experience and management of knowledge among teachers who are in the process of retiring from the FE and teachers recently engaged (Flores, 2010). Currently, the YouTube Channel has 268 subscribers and 6,544 visits, and the videos have had from 24 up to 1,800 views.

By the implementation of VLE in the FE, as mentioned by Diaz, De Luna & Salinas (2019), there now are supporting tools for academic levelling, which enables taking distance courses at the same time classroom attendance is done –even in weeks prior to the beginning of classes– aimed to strengthen academic weaknesses students bring from the high-school level when they enter first semester, or, to reinforce the necessary topics for serial subjects. At the Covid-19 contingency, classroom classes were discontinued and classes had to migrate to virtual platforms to continue the educational processes. Prior use of the FE of VLE has favored, in a way, transit towards distance teaching, both for students and teachers of the common core. In spite of this, in the face of the emergency situation, what has been done is not enough (Borges, 2020); as aspects of teaching training have to be strengthened, infrastructure, as well as pedagogic and

assessment strategies, to reconsider education and to respect the relevance of interaction between professors and learners.

Implementation of these strategies set the basis for subsequently adopting standardized processes in the development of this type of environments, that may increase the degree of robustness of the platforms used, by means of mechanisms for interoperability aimed to facilitate the exchange of content between different VLE, whereby digital resources placed therein would be enriched and the scope towards the student and teaching community of the university. In this sense, there are previous works in the institution (Castro *et al.* 2014; Justo, 2018) where models, guidelines and recommendations are formally presented for the development of interoperable VLE.

CONCLUSION

The results of the study show that strategies implemented were positive, whereas failure indexes of the studied learning units show a decrease as of 2017. Therefore, this research contributes validation of educational strategies that may be replicated in other educational contexts, with confidence that as the proposed methodology is followed, similar results may be reached. It believed that, in addition to the benefits provided by VLE, the results were reinforced by supporting programs implemented at the FE –added to the work done by teachers in the classroom– such as academic counseling programs taught by high performance students, tutorships and follow-up by full-time teachers to groups of students in risk situations.

The foregoing has caused the situation of students in the common core to improve and that students' lagging be mitigated, so much so that in 2020-2 the number of students who finished the common core and improved the course exceeded the number of spaces reserved for them in the different educational programs of engineering. There is no question that there still is work to be done, for example, to assess the impact of developed educational videos on motivation, and on the academic achievement of students. To cure this, learning scenarios will be designed where students would consult the resources, and the results would be compared between the groups that followed this methodology and groups that have used other means of support. Likewise, it is necessary to carry out an assessment with teachers on their perception on the use of the Blackboard Ultra environment as supporting tools to conduct classroom attendance and distance learning.

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HOW TO CITE

Justo López, Araceli Celina; Castro García, Lorena; Aguilar Salinas, Wendolyn Elizabeth; De las Fuentes Lara, Maximiliano. (2021). Digital educational strategies to support basic engineering science courses. *Apertura*, *13*(1), pp. 52-67. http://dx.doi.org/10.32870/Ap.v13n1.1983