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Artículos científicos

Recursos digitales como apoyo en la enseñanza del cálculo

Digital resources as support in the teaching of calculus

Recursos digitais para apoiar o ensino de cálculo

Ulises Daniel Barradas Arenas
Colegio de Educación Profesional Técnica de Estado de Campeche, México
ulises.barradasa.acad021@cam.conalep.edu.mx
https://orcid.org/0000-0001-7122-6582

Resumen

La evolución de la enseñanza del cálculo avanza de manera muy rápida, de ahí que la incursión de nuevas tecnologías de la información en el proceso educativo se haya vuelto clave. En tal sentido, algunos estudiantes han presentado problemas con todos estos cambios y requieren de nuevas metodologías con las cuales puedan generar aprendizajes significativos, lo que implica diseñar las herramientas necesarias para lograr los aprendizajes esperados. Por tanto, esta investigación tuvo como objetivo evaluar el nivel de impacto de los recursos digitales como apoyo en la enseñanza del cálculo para disminuir la reprobación. Como metodología se empleó un enfoque mixto y de tipo correlacional. Para eso, se probaron algunos instrumentos y resultados con métodos estadísticos. Como resultado se obtuvo que los estudiantes se identificaron con los contenidos en formato de video, lo cual genera aprendizajes significativos en ellos. En cuanto a las actividades desarrolladas en la plataforma, a los estudiantes se les facilitaron algunas individuales, integradoras y colaborativas. Del total de participantes, solo 26 % acreditó el curso, por lo que se requiere un análisis pedagógico detallado de las necesidades de los estudiantes antes de integrar las herramientas tecnológicas. Aun así, los contenidos y el diseño del curso fueron aceptados en su totalidad por los estudiantes, mientras que en lo que corresponde al trabajo del facilitador, 66 % consideró que fue acorde al curso.

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Palabras clave: aprendizajes significativos, enseñanza híbrida, diseño instruccional, herramientas tecnológicas, reprobación.

Abstract

The evolution of the teaching of calculus advances very quickly, the incursion of the use of new information technologies in the teaching-learning process has become key in this process, some students have presented problems with all these changes and require new methodologies with which they can generate significant learning, this means designing the necessary tools to achieve the expected learning, therefore, this research aims to evaluate the level of impact of digital resources as support in the teaching of calculation to reduce the Failure in the subject of calculation with the use of technological tools, as a methodology of this research a mixed and experimental approach of a correlational type was carried out in which some instruments and results were tested with statistical methods and the progress was observed through virtual work during its application, as a result, q That students identify with the video content and that these generate significant learning in them, within the activities developed on the platform, students are facilitated with integrative activities and show little response in collaborative activities, of the total sample only 26% accredited the course, therefore, it is required to carry out a detailed pedagogical analysis of the students' needs before integrating the technological tools, the contents and course design were fully accepted by the students, in what corresponds to the Facilitator's work, only 66% considered that it was according to the course.

Keywords: Meaningful learning, hybrid teaching, instructional design, technological tools, failure.

Resumo

A evolução do ensino de cálculo está avançando muito rapidamente, por isso a incursão das novas tecnologias da informação no processo educacional tornou-se fundamental. Nesse sentido, alguns alunos têm apresentado problemas com todas essas mudanças e exigem novas metodologias com as quais possam gerar aprendizagens significativas, o que implica desenhar as ferramentas necessárias para alcançar a aprendizagem esperada. Portanto, esta pesquisa teve como objetivo avaliar o nível de impacto dos recursos digitais como suporte no ensino de cálculo para redução de falhas. A metodologia utilizada foi uma abordagem

mista e correlacional. Para tanto, alguns instrumentos e resultados foram testados com métodos estatísticos. Como resultado, obteve-se que os alunos se identificaram com o conteúdo em formato de vídeo, o que gera aprendizagem significativa nos mesmos. Relativamente às atividades desenvolvidas na plataforma, os alunos realizaram algumas atividades individuais, integrativas e colaborativas. Do total de participantes, apenas 26% credenciaram o curso, por isso é necessária uma análise pedagógica detalhada das necessidades dos alunos antes de integrar as ferramentas tecnológicas. Mesmo assim, o conteúdo e o desenho do curso foram totalmente aceitos pelos alunos, enquanto no que corresponde ao trabalho do facilitador, 66% consideraram que era consistente com o curso.

Palavras-chave: aprendizagem significativa, ensino híbrido, design instrucional, ferramentas tecnológicas, fracasso.

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Introduction

The constant changes that occur in education make it necessary to link information technologies to the teaching-learning processes, especially in mathematics subjects, where - according to school control data in the 2019 and 2020 cycles - half of students fail the calculus chair. Therefore, this research aims to evaluate the level of impact of digital resources in the teaching of calculus in the fifth semester of high school (technical career in computer science, afternoon shift). For this, the following hypothesis was taken as a basis: the project of digital resources in the teaching of calculus could be an ideal tool to reduce failure. In short, this project proposes the integration of excellent quality content, which is designed so that students can access them from any electronic device at any time.

The research is divided into four stages: the first related to the institutional context, the antecedents and the state of the art; the second with the development and implementation of the materials; the third with the collection of information, and the last with the analysis and presentation of the results.

Regarding the instruments, two were used: a diagnostic evaluation and a satisfaction survey. The first showed that the students have a particular interest in the materials in video

format, while the second instrument showed that the students identify with the structure of the contents and materials developed on the platform and the integrative activities.

Literary review

The educational model of the College of Technical Professional Education is focused on the elements of the comprehensive reform of upper secondary education (RIEMS), and aims to train human resources by integrating basic and professional skills with the possibility of continuing with higher level studies (From Ibarrola, 2018).

This model provides a solid occupational and academic training in order to respond to the productive sector through quality human resources, for which it is articulated in three axes: constructivism, education for sustainable development and training based on competencies (De Ibarrola, 2018).

Regarding the teaching of calculus, this is an area of research that has had a boom in the last decade, with the integration of information technologies to develop new methodologies with which the teaching-learning processes can achieve a greater degree of effectiveness.

Now, when designing virtual environments, a didactic strategy is used that seeks to generate substantial changes, which start from the interaction with various digital media outside of a conventional classroom. In other words, in the virtual field, the teacher acts as a guide while the students must face the responsibility of acquiring new learning experiences (Gutiérrez Mendoza, Ariza Nieves and Jaramillo Mujica, 2014). In addition, the diversity in the training of students requires that they have different learning rhythms, which is why the design of courses supported by b-learning modalities is essential (Hernández Chérrez, 2014) that can be supported by a wide range of tools. In this regard, Duarte and Guevara (2018) mention the following:

> The GeoGebra software allows the creation of multiple digital educational resources that facilitate the teaching process of the concepts related to calculation, since the material that is available on the network satisfies the exploration, conceptualization and evaluation of most of the topics that are found. within the mathematics curriculum (p. 77).

For its part, innovation within the classroom is a responsibility that teachers must have at all times, since digital technology requires constant updating in new discoveries and technological developments. As teachers, using and reusing this type of technology is part of an innovative educational perspective (Salinas *et al*., 2013).

> Audiovisual media can be a viable resource for the reinforcement of what has been learned in comprehensive calculus class, this due to the impact that digital media, the internet and social networks have on young students. Now we need to do practical tests with the videos to know if they really have a positive impact, providing the resource to the students during the integral calculus course and to know if this improves the performance of half of the students who said they had difficulties in understanding of matter (Vargas Amaro y Mondelo Villaseñor, 2018, p. 3108).

Other resources are blogs, with which favorable results have been achieved due to the proactive design for students and, above all, due to the quality of the content and the presentation in the teaching of calculus (Rincón, Vergel & Ortega, 2015).

In short, the aforementioned antecedents refer to various cases of the use of technological resources, methodologies and techniques that serve as a means for teaching calculus.

Failure of mathematics in the upper medium

According to statistical data from the Ministry of Public Education (SEP), the following were the school dropout and failure rates during the 2016-2017 period.

Tabla 1. Abandono y reprobación escolar 2016-2017

Nivel	Abandono	Reprobación
Primaria	0.7 %	0.8 %
Secundaria	4.2 %	4.9 %
Bachillerato	12.8 %	13.7 %

Nota: Esta tabla describe los porcentajes de abandono escolar tomados del formato 911.

Fuente: Elaboración propia

Another aspect that impacts school dropout is the transition from high school to upper secondary level. According to Solís (2018), the factors that influence this process are:

1. Universal coverage. One in three young people has the opportunity to be part of upper secondary education and by 2021 it is predicted to achieve 90%.
2. The lag within high school. During 2015, 18% of young people between the ages of 16 and 17 did not finish high school, which is why they did not achieve access to upper secondary education.
3. Gaps within the states. This impact is mainly due to socioeconomic and marginalization factors.
4. Territorial effects. Migration and the lack of quality job opportunities generate serious problems of access to upper secondary education.
5. Socio-economic and educational resources. The lack of stable economic conditions produces a high level of inequality and opportunity to access upper secondary education.
6. Family circumstances. Family dysfunction causes young people to have to look for options to survive due to the lack of support from their parents; This type of situation leaves them at a disadvantage in terms of access to upper secondary education.

Based on the above, the teaching of mathematics in Mexico urgently requires a change, since - according to the SEP (2017) - 50% of students fail this subject at all educational levels. Likewise, according to the National Institute for the Evaluation of Education (INEE), estimates of failure rates in the subject of mathematics are very high: between 60% and 80%, depending on the educational level (INEE, 2012). To reverse this situation, researchers such as Chacón (2000) mention that an affection towards mathematics must first be provoked in order to achieve its proper mastery.

In this sense, teachers have to be aware that information and communication technologies (ICT) provide the possibilities of access to online resources that use a combination of formats (audio, video and graphics), which always favors learning and when the appropriate didactic strategies are used (Castillo-Sánchez, Gamboa-Araya and Hidalgo-Mora, 2008).

As Fernández Naranjo and Rivero López (2014) mention, teachers must radically change the traditional teaching of mathematics and implement new information technologies to create greater dynamism, which will motivate and awaken the interest of students. In fact,

student failure significantly affects teachers' attitudes, which are related to the ability, disposition, vision and usefulness of teaching mathematics (Castañeda González and Álvarez Tostado, 2004).

To all this, according to Juárez and Limón (2013), the preparation of a teacher in the area of mathematics is of vital relevance, which includes not only specialized knowledge of the content, but also pedagogical and didactic knowledge of said discipline to teach it as something open and fully applicable in all areas of real life. Logically, this means breaking schemes and becoming a motivating factor for students through the inclusion of quality technological tools. (Flores Moreno, Elizondo Cantú y García Quiroga, 2014).

For this reason, teachers should not focus only on making known the thematic contents of the subject, but should also consider the affective and metacognitive factors of their students in order to reduce the difficulties presented in learning mathematics (Herrera Villamizar, Montenegro Velandia and Poveda Jaimes, 2012). In the words of Elizondo (2018), the student's lack of conception in the mental relationship of the problem that he performs supports him in a theoretical perception that makes it difficult for him to analyze and understand the problems.

Teaching-learning strategies as a means to reduce failure in mathematics

For the learning process to be carried out correctly, the student must have a disposition and motivation towards the content he studies. For this, active learning is key as a didactic strategy, since it allows the student to be a leading entity in the acquisition of knowledge, which will undoubtedly favor the development of meaningful learning (Rincón et al., 2014).

Likewise, the teacher's relationship with the student within the subject is one of the points that is associated with failure, since negative attitudes demotivate students and impact performance, which generates a negative predisposition (Romero, Utrilla -Quiroz and Utrilla-Quiroz, 2014).

The use of problem solving models by the teacher is a technique that favors student learning. In this regard, Calvo Ballestero (2008) mentions that the use of mathematical models to solve problems plays a vital role in the teaching process.

According to Herrera Cano et al. (2013), didactic materials must be developed that address complex topics, which are supportive in the subject and can facilitate the teaching-learning process.

Another type of strategy is playful activities. In these, the student interacts with the subject through games and creatively, which causes learning and reduces failure. On this, Góngora and Balán (2007) explain that such activities in the school environment not only promote learning, but also become an instrument of exploration to promote other improvement options.

The use of integrative strategies also offer excellent results in the problem of failure, hence it is important to carry out a diagnostic evaluation at the beginning of each course, since it provides a clear overview of the previous concepts that students have (Carreón Rodríguez, Díaz Camacho, Pérez Merlos and Salgado Gallegos, 2015).

According to Briseño et al. (2017), constantly evaluating also helps in understanding topics and cultivates a taste for the subject, since a better understanding is acquired and increases performance and knowledge retention, which helps to avoid school dropouts.

Finally, it can be ensured that the student's motivation depends on multiple factors, such as a good diet, the constant support of their teachers and non-conventional activities based on technology.

Technological tools to support the teaching of calculus

GeoGebra is a tool that motivates collaborative and constructivist work, so it is based on the interaction between the different work groups and the teacher through inter-learning processes. This platform offers a variety of options for mastering geometry, algebra, and calculus in a fully connected, compact, and easy-to-use software environment.

GeoGebra had its origins with the aim of supporting students in the acquisition of knowledge related to mathematics. In this environment, students can manipulate variables and objects in a very simple way within a plane, which allows solving a great variety of problems through dynamic mathematics and research (Barahona Avecilla, Barrera Cárdenas, Vaca Barahona and Hidalgo Ponce, 2015).

Another tool is the Mathematica software, which generates a decrease in time in complex mathematical calculations, especially in advanced topics that integrate various algebraic operations. A clear example of this is mentioned by Vílchez (2007) in the interview with Monge Fallas:

> He reported on the various pedagogical uses that Mathematica software has been given in this academic unit, mainly to support teaching in courses of the Computer Aided Mathematics career. According to Monge, Mathematica has been used in courses as a programming and calculation tool. In the Virtual Magazine produced by this last institution, the use of WebMathematica has been fundamental to put online virtual courses such as Probability Calculus and Superior Calculus. (p. 57).

The use of free software is a tool of great value in the teaching of mathematics because it generates a better understanding of the thematic content and its practical application. In this regard, Abánades, Botana, Escribano and Tabera (2009) mention:

> The use of free mathematical software is becoming increasingly important, not only from a practical point of view, but also from a conceptual point of view. We have not tried to give an exhaustive list of all available free mathematical software, rather we have tried to show some valuable pieces of software that can be of great use to the mathematical community. We can only encourage mathematicians to approach free software, and to use, modify, improve and disseminate it, with complete freedom (p. 21).

According to Bayón et al. (2011), summarizes some of the advantages of these tools: 1) economic, for these do not require licenses like other programs which are almost impossible to acquire for a traditional student, 2) legal, they can be distributed within the students without legal consequences, 3) scientific, they have a close relationship, since they are used within the scientific field, 4) formative, their updating is constant, so there is a lower risk of becoming obsolete, 5) philosophical, with these it seeks to transmit values to students.

In this sense, for Ávila, Chourio, Carniel and Vargas (2007), students who work with software are benefited in their teaching-learning process, since its use allows them to carry out demonstrations and reflections, which gives the teacher the possibility to raise new hypotheses within the group.

However, it should be noted that the implementation of educational software tools does not guarantee, in all cases, that students have a good understanding of the content. However, if they are used well, they can be of great support to students and teachers.

Methodology

This work was based on a mixed approach, since the information collected was analyzed quantitatively and qualitatively. According to Otero Ortega (2018), "this research process collects, analyzes and interprets qualitative and quantitative data that the researcher considers necessary in his study" (p. 19).

Likewise, the project design had a correlational approach for the quantitative part, since the results of each of the variables were involved to test the hypothesis based on statistical methods. In addition, a multiple case study was used for the qualitative part, where a systematic analysis of the observed group was sought.

The sample was selected intentionally, that is, students from the fifth semester (group A) of the computer science technical career (afternoon shift). This shift was chosen because students have more serious problems in their school performance compared to the morning shift population.

The instruments used —based on the Likert scale— were two surveys divided as follows:

1. Initial instruments: Composed of 16 questions divided into three sections: transmissive, active and interactive digital resources. The objective was to measure which of these means students use to generate their learning in the subject in a meaningful way.
2. Final instrument: Composed of 37 questions divided into two sections to measure the levels of satisfaction with the instructional design of the course and the facilitator's work.

Based on the objective and the hypothesis presented, the steps followed are mentioned below:

a) Application of the initial instrument via email with the support of the Google questionnaire tool.
b) Validation of the instrument by Cronbach's alpha statistical method.
c) Development of learning resources based on instrument results.
d) Instructional design of the course through the support of the Moodle platform.
e) Preparation of the course evaluation instruments.
f) Registration of students within the platform.

g) Follow-up of the students for 30 days that the course lasts.

h) Application of the closing instrument and analysis of the results.

i) Conclusions of the final project.

Project development and implementation

Based on the application of the initial instrument (which aims to measure which means the students use to generate their learning in the subject in a meaningful way), the following variables were established: transmissive digital resources, active digital resources and interactive digital resources.

Tabla 2. Variables e indicadores

Variables	Indicadores	Número de reactivos
Recursos digitales transmisivos	Imágenes y tutoriales	3
	Sitios en internet y bibliotecas virtuales	2
Recursos digitales activos	Simuladores y juegos	4
	Programas expertos y buscadores	4
Recursos digitales interactivos	Sistemas de mensajería	2
	deoconferencias y videos	1

Fuente: Elaboración propia

The validation of the instrument - made up of 16 questions based on the Likert scale - showed the following:

Tabla 3. Estadísticas de fiabilidad

Alfa de Cronbach	Alfa de Cronbach basada en elementos estandarizados	N.° de elementos
.844	.855	16

Fuente: Elaboración propia

According to Quero Virla (2010), in what corresponds to the reliability scale of the instrument using Cronbach's alpha, it mentions the following:

Tabla 4. Rango de confiabilidad

Rangos	Magnitud
0.81 – 100	Muy alta
0.61 – 0.80	Alta
0.41 – 0.60	Moderada
0.21 – 0.40	Baja
0.01 – 0.20	Muy baja

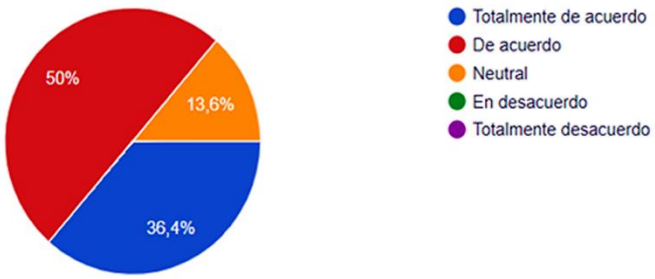
Fuente: Elaboración propia

Therefore, the instrument applied to the students showed a high degree of reliability.

Analysis of instrument 1 results

Based on the results of instrument 1, it can be indicated that students consider that games are not a good alternative to generate learning. Regarding the other variables, these are identified to a greater degree with audiovisual materials (59.1%); Furthermore, only 36.4% consider that the use of websites is the best option when searching for information to carry out their activities (figure 1).

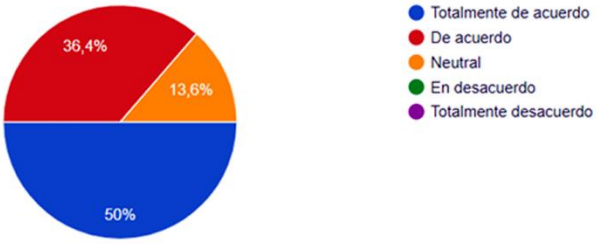
Figura 1. Recursos transmisivos (sitios en la web)



Fuente: Elaboración propia

Regarding active digital resources, 40.9% identify with the use of computer programs as support in their activities and 50% consider that expert systems are key in understanding each of the issues (figure 2). However, only 50% use translators and digital multimedia resources.

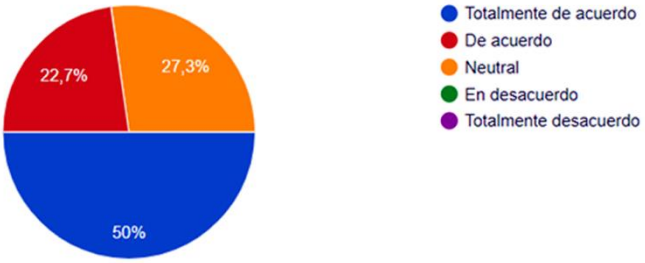
Figura 2. Recursos digitales (sistemas expertos)



Fuente: Elaboración propia

Regarding interactive digital resources, 54.5% use email, forums and blogs as a means of communication in the development of their activities and 50% use messaging and videoconferencing systems (figure 3).

Figura 3. Recursos interactivos síncronos



Fuente: Elaboración propia

Conclusions of the application of instrument 1

According to the exposed results, it can be assured that there is a trend for materials that include video, audio and productivity tools. Likewise, the means of interaction that they consider to be the most suitable is email for asynchronous communication and videoconferencing for synchronous communication.

Development of materials and integration into the platform

According to the results obtained from the initial instrument, the course contents were developed in the free software tool ExeLearning. This was selected due to its free use and the integration of all the elements for which students are most attached, according to the study carried out.

The platform chosen to teach the remedial course was Moodle and the thematic content was divided as follows:

Unit 1. Derivatives.

- Algebraic.
- Exponential and logarithmic.
- Trigonometric.

Unit 2. Integral

- Immediate.
- Defined.

In the case of unit 1, the contents were as follows:

Figura 4. Portada contenido temático derivadas

Fuente: Elaboración propia

The structure and information of the topics were embedded within the platform from an ExeLearning content, as follows:

Figura 5. Contenidos en ExeLearning tema derivadas

Fuente: Elaboración propia

As we can see, the thematic contents are shown in the menu on the left side; These include the audio and video elements with which the students will be able to guide themselves in the elaboration of their activities.

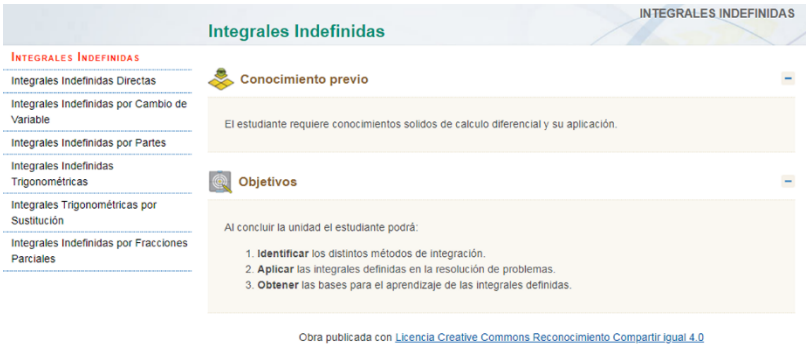
In the case of the thematic content of integral calculus, its format was very similar to the previous one. This was divided into two themes: definite and indefinite integrals.

Figura 6. Portada contenido temático integrales

Fuente: Elaboración propia

The structure of the contents within the ExeLearning tool was as follows:

Figura 7. Contenidos en ExeLearning tema integrales

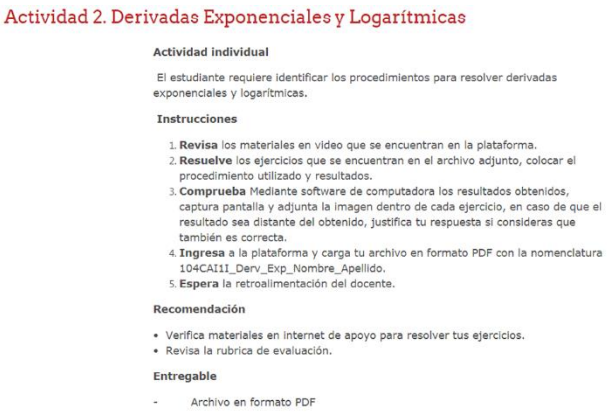


Fuente: Elaboración propia

The development of the activities was divided into individual activities which are those that the students develop with the learning obtained within the platform and with the support of the teacher.

In total, two individual activities were designed: one for integral calculation and one for differential. Both are intended for students to identify procedures and be able to use support software to corroborate their results. An instructional design is carried out to develop each of these, as shown in Figure 8.

Figura 8. Diseño instruccional de las actividades individuales



Fuente: Elaboración propia

The activities contain their respective evaluation rubrics with which the students are guided in the steps to follow for their elaboration.

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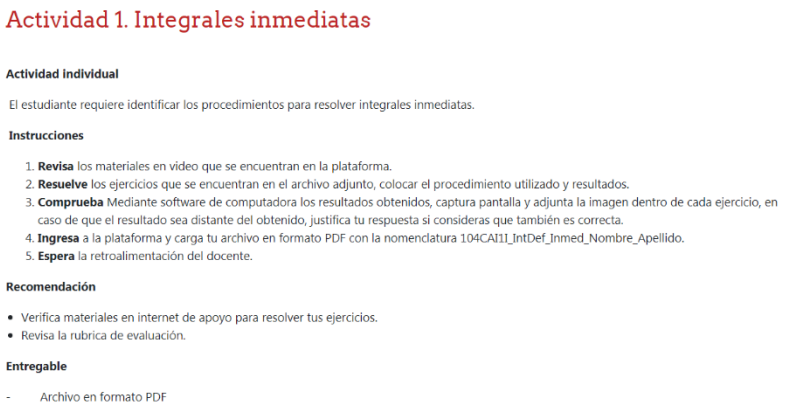
Collaborative activities are those that integrate the work of several colleagues in search of common learning, two collaborative activities were designed (one for each topic). These aim to generate new knowledge of each one of the students in a collaborative way and the feedback to enrich the learning of the students; The layout of the activity is shown below:

Figura 9. Diseño instruccional de las actividades colaborativas



Actividad 1. Integrales inmediatas

Actividad individual

El estudiante requiere identificar los procedimientos para resolver integrales inmediatas.

Instrucciones

1. **Revisa** los materiales en video que se encuentran en la plataforma.
2. **Resuelve** los ejercicios que se encuentran en el archivo adjunto, colocar el procedimiento utilizado y resultados.
3. **Comprueba** Mediante software de computadora los resultados obtenidos, captura pantalla y adjunta la imagen dentro de cada ejercicio, en caso de que el resultado sea distante del obtenido, justifica tu respuesta si consideras que también es correcta.
4. **Ingresa** a la plataforma y carga tu archivo en formato PDF con la nomenclatura 104CAI11_IntDef_Inmed_Nombre_Apellido.
5. **Espera** la retroalimentación del docente.

Recomendación

- Verifica materiales en internet de apoyo para resolver tus ejercicios.
- Revisa la rubrica de evaluación.

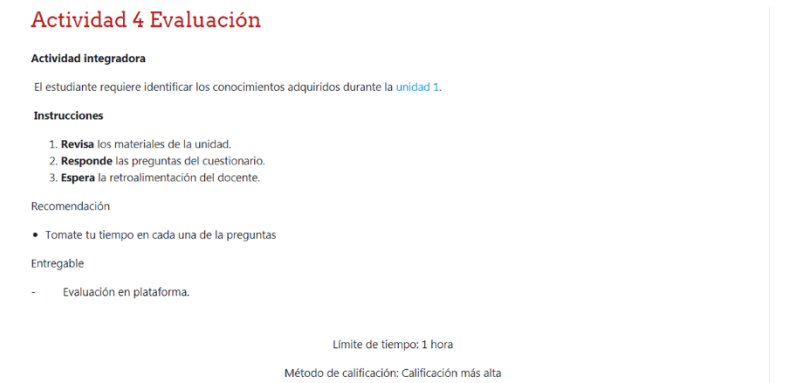
Entregable

- Archivo en formato PDF

Fuente: Elaboración propia

The integrative activities summarize the learning obtained from each of the topics. Two integrative activities were developed with the questionnaire tool for each of the topics; These are aimed at integrating the knowledge acquired. The layout of the activity is shown below:

Figura 10. Diseño instruccional de las actividades integradoras



Actividad 4 Evaluación

Actividad integradora

El estudiante requiere identificar los conocimientos adquiridos durante la unidad 1.

Instrucciones

1. **Revisa** los materiales de la unidad.
2. **Responde** las preguntas del cuestionario.
3. **Espera** la retroalimentación del docente.

Recomendación

- Tomate tu tiempo en cada una de la preguntas

Entregable

- Evaluación en plataforma.

Límite de tiempo: 1 hora

Método de calificación: Calificación más alta

Fuente: Elaboración propia

Analysis of results

Based on the results obtained from the project in which 30 students and a teacher facilitator interacted, the following could be observed:

Tabla 5. Resultados de participación

Actividad	Porcentaje de participación
Individual	60 %
Colaborativa	15 %
Integradora	75 %

Fuente: Elaboración propia

As we can see, the students showed little interest in collaborative activities compared to individual and integrative activities.

Regarding the correct resolution of the activities, the results obtained were the following:

Tabla 6. Resultados de actividades acreditadas

Actividad	Porcentaje de participación
Individual	40 %
Colaborativa	15 %
Integradora	40 %

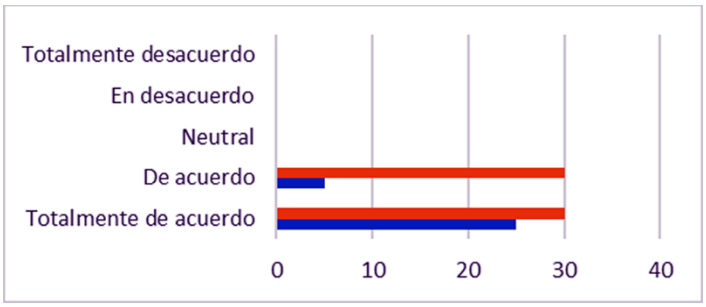
Fuente: Elaboración propia

Of the individual activities, only 12 students had more than 60% of the correct exercises. In the case of collaboratives, all the students who participated had their results correct; finally, in the integrative activities, 12 students accredited the evaluations of each of the activities. In total, only 26% of the students accredited the course for the inter-monthly period.

Regarding the final instrument (whose objective was to measure the levels of satisfaction with the instructional design of the course and the facilitator's work), the following results were obtained. According to the thematic contents included in the design

of the course, 66% totally agree and 33% agree that they are adequate for understanding the topics. The congruence of the contents with the developed activities showed that 83% of the students totally agree and 17% agree that they have a direct relationship with each of the proposed activities. This is shown in figure 11:

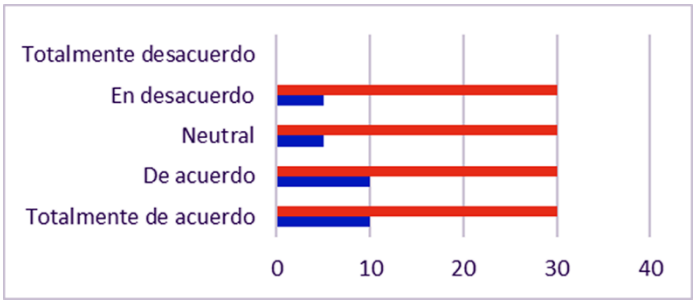
Figura 11. Congruencia en contenidos y actividades



Fuente: Elaboración propia

Regarding the design of the instructions for the activities within the platform, 66% fully agree, 17% agree and 17% neutral. We can see that 83% consider each of the instructions for the activities carried out to be understandable. According to the work of the facilitator teacher (regarding monitoring, feedback, content mastery and evaluation), 33% totally agree, 33% agree, 17% neutral and 17% disagree.

Figura 12. Trabajo docente

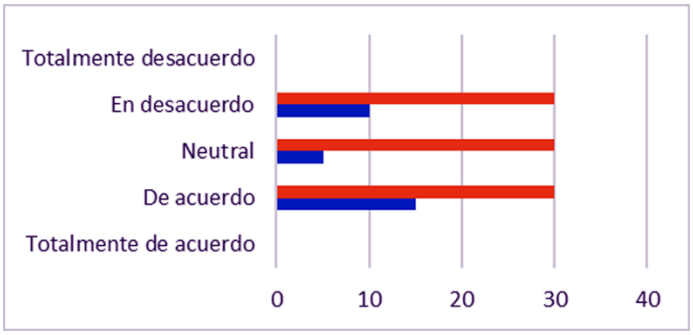


Fuente: Elaboración propia

It is important to mention that the facilitator teacher who participated in the project did not have much experience in teaching this type of course.

According to the work of the students within the platform (regarding the elaboration of activities, review of sources of consultation and participation), 50% agreed, 13% neutral and 34% disagreed.

Figura 13. Trabajo de estudiantes



Fuente: Elaboración propia

Discussion of the results

The use of digital resources as support in the teaching of calculus has been very useful for both teachers and students. In this sense, tools such as GeoGebra, Mathematica, among others, are of great support in the development of integrative activities, which can generate learning in a simpler way, although it is worth noting that none of these guarantees adequate monitoring. Therefore, the intervention of the design and the follow-up of the teacher are fundamental. In this regard, Salinas et al. (2013) explain that digital technology requires constant updating in new discoveries and technological developments.

On the other hand, the implementation of the platform and the design of digital resources are innovative and provide a series of options to students so that they have a quality understanding of each of the topics. Therefore, Rincón et al. (2015) consider that a proactive design for students, especially in the quality of the contents and the presentation, enhances the tools in the teaching of calculus.

For their part, Flores Moreno et al. (2014) emphasize that teachers must break schemes and become a motivating factor for students through the inclusion of quality technological tools, because when a student is motivated, the probability of failure is reduced. In accordance with this idea, Fernández and Rivero (2014) assure that the traditional teaching

of mathematics must be radically changed and new information technologies implemented to generate opportunities for dynamism and motivation within the classes.

Finally, it can be said that there is still a long way to go and work on the part of the teacher to analyze the results of each of the tools that he uses in his daily life.

Conclusions and final considerations

According to the hypothesis raised, the project of digital resources as a support in the teaching of calculation could be a support tool in the reduction of failure, since it was shown that of the total sample only 26% managed to accredit the course.

Likewise, according to the analysis of instrument 1 (used to measure which means students use to generate their learning in a meaningful way in the subject), it can be said that students prefer transmissive digital resources, which correspond to the management of tutorials (59.1 %) and websites (36.4%). In addition, active digital resources in image-generating programs (40.9%) and expert systems (50%), as well as asynchronous (54.5%) and synchronous (50%) interactive digital resources. The latter means that students are more attached to the use of emails and text messaging as a means of communication, while video materials are the most used for consultation.

On the other hand, it can be pointed out —through the final instrument— that for the students the content design of the course was of high quality (83%). In addition, 66% observed congruence in each of the activities within the platform, 33% considered that the facilitator carried out his work correctly as a course guide and 50% of the students complied with each of the activities and reviewed the contents of the platform. However, in the development of individual activities only 60% developed them and 40% of the results were correct. In collaborative activities, 15% interacted and developed them correctly, and in integrative activities, 75% presented them (40% were correct).

Therefore, it can be concluded that the follow-up by the facilitators in each of the courses should be reinforced and analyze in detail how to integrate students into teamwork in this type of modality.

Future lines of research

As a future line of research, it is proposed to elaborate a work that analyzes the pedagogical needs of the students and integrate them into this project to determine if the design of the contents explained in this document can have a favorable impact on the learning of the students.

Likewise, it is proposed to implement the project in a general way on the campus, since - according to the results obtained - the integration of parents is needed in monitoring the activities of the students.

Finally, some of the challenges presented by this project is the monitoring of the operation of the four axes, since it must be constantly fed. In addition, pay attention to the frequent absences of some students, which requires the participation of teachers, administrators and parents to propose improvements and adjustments.

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