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XVI Congreso de Matemática Aplicada

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June 14-18, 2021

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Universidad de Oviedo

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Foreword

It is with great pleasure that we present the Proceedings of the 26th Congress of Differential Equations and Applications / 16th Congress of Applied Mathematics (XXVI CEDYA / XVI CMA), the biennial congress of the Spanish Society of Applied Mathematics S$\vec{e}$MA, which is held in Gijón, Spain from June 14 to June 18, 2021.

In this volume we gather the short papers sent by some of the almost three hundred and twenty communications presented in the conference. Abstracts of all those communications can be found in the abstract book of the congress. Moreover, full papers by invited lecturers will shortly appear in a special issue of the S$\vec{e}$MA Journal.

The first CEDYA was celebrated in 1978 in Madrid, and the first joint CEDYA / CMA took place in Málaga in 1989. Our congress focuses on different fields of applied mathematics: Dynamical Systems and Ordinary Differential Equations, Partial Differential Equations, Numerical Analysis and Simulation, Numerical Linear Algebra, Optimal Control and Inverse Problems and Applications of Mathematics to Industry, Social Sciences, and Biology. Communications in other related topics such as Scientific Computation, Approximation Theory, Discrete Mathematics and Mathematical Education are also common.

For the last few editions, the congress has been structured in mini-symposia. In Gijón, we will have eighteen minis-symposia, proposed by different researchers and groups, and also five thematic sessions organized by the local organizing committee to distribute the individual contributions. We will also have a poster session and ten invited lectures. Among all the mini-symposia, we want to highlight the one dedicated to the memory of our colleague Francisco Javier "Pancho" Sayas, which gathers two plenary lectures, thirty-six talks, and more than forty invited people that have expressed their wish to pay tribute to his figure and work.

This edition has been deeply marked by the COVID-19 pandemic. First scheduled for June 2020, we had to postpone it one year, and move to a hybrid format. Roughly half of the participants attended the conference online, while the other half came to Gijón. Taking a normal conference and moving to a hybrid format in one year has meant a lot of efforts from all the parties involved. Not only did we, as organizing committee, see how much of the work already done had to be undone and redone in a different way, but also the administration staff, the scientific committee, the mini-symposia organizers, and many of the contributors had to work overtime for the change.

Just to name a few of the problems that all of us faced: some of the already accepted mini-symposia and contributed talks had to be withdrawn for different reasons (mainly because of the lack of flexibility of the funding agencies); it became quite clear since the very first moment that, no matter how well things evolved, it would be nearly impossible for most international participants to come to Gijón; reservations with the hotels and contracts with the suppliers had to be cancelled; and there was a lot of uncertainty, and even anxiety could be said, until we were able to confirm that the face-to-face part of the congress could take place as planned.

On the other hand, in the new open call for scientific proposals, we had a nice surprise: many people that would have not been able to participate in the original congress were sending new ideas for mini-symposia, individual contributions and posters. This meant that the total number of communications was about twenty percent greater than the original one, with most of the new contributions sent by students.

There were almost one hundred and twenty students registered for this CEDYA / CMA. The hybrid format allows students to participate at very low expense for their funding agencies, and this gives them the opportunity to attend different conferences and get more merits. But this, which can be seen as an advantage, makes it harder for them to obtain a full conference experience. Alfréd Rényi said: "a mathematician is a device for turning coffee into theorems". Experience has taught us that a congress is the best place for a mathematician to have a lot of coffee. And coffee cannot be served online.

In Gijón, June 4, 2021

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Teaching experience in the Differential Equations Semi-Virtual Method course of the Tecnológico de Costa Rica

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Abstract

In 2018, the Differential Equations course for Engineering students is incorporated into the CEDA-TEC Digital Teaching Vice-Rector's Project. The main objective of this work is to disclose my teaching experience in the hard labor of planning, implementation, creation of materials and evaluation of the aspects that are carried out and implemented in this course under the semi-virtual modality.

Finally, it shows some relevant results obtained in an assessment questionnaire about the course applied to the students.

1. Introduction

In 2018 the idea was born from CEDA (Academic Development Center)-Tecdigital to virtualize the course of differential equations in the engineering area therefore, this article shares teaching experience on its planning, creation-development of teaching materials and support, implementation in the classroom, evaluative aspects and also some results obtained in evaluation questionnaire applied to students of the course under which this modality was applied.

2. Semi-virtual mode course planning (bimodal)

It is important to know that in our case a semi-virtual course is understood as the one in which we work every week under two types of classes:

In Person, It consists of a two-hour classroom class, where the teacher is simply a guide or mediator of the process and the student is the main participant and builder of knowledge. During these face-to-face sessions, the teacher makes a theoretical presentation with illustrative examples of the topics covered, clarifies doubts in semi-virtual class and plans the learning activities in the classroom in such a way that they allow the student to achieve collaborative work and through a type of flipped learning.

Virtual, in this type of class, the student works at home (or another place of study that he/she deems appropriate) on the course contents that were previously assigned by the teacher through guidance from said class, this can be based on carrying out a didactic guide, assigned work exercises, view videos and some support material such as books or applications made in software.

The Tecdigital platform will be used as a means of communication on the planification, visualization and interaction to realize the distinct activities inside or outside of the classroom each week.

As a first stage in the first semester of 2018, a course on planning and instructional design is carried out to teachers from various areas of the CEDA (Center for Teaching Development) department of training of the Technological of Costa Rica. The initial objective of the course is to know about basic principles of instructional design for virtual learning environments, learning experiences and educational resources for virtuality, evaluation of learning in virtuality and all the above with the great purpose of planning and developing the design or planning of the own specific course in our case of differential equations under this modality. In it, the following aspects are considered:

- **Population**

  Students of the course are typical of engineering careers, said student population requires as requirements to have passed courses in differential calculus and linear algebra, students attend between the IV and V semester of their study plans, maximum per group is 32 students.

- **Duration**

  The course lasts 16 weeks with a weight of 4 credits for 12 hours per week, distributed as follows: 2 face-to-face hours, 2 face-to-face consultation and 8 work independently at home or another appropriate place.

- **Curriculum design and organization**

  In this segment, aspects of instructional planning or design are organized and stipulated in a matrix form in the most explicit and detailed way.

Week #	Objectives	Contents	Learning Experiences	Means, materials and resources	Assessment

3. Creation of teaching materials and support

Once the instructional design has been prepared and reviewed by experts in the area, the preparation of the didactic and support materials embodied in such planning proceeds in a second stage. Each of them is briefly described below.

3.1. Teaching guides

A few weeks back, didactic guides were developed with the purpose of educating under guidance given by the teacher to put into practice knowledge acquired on topics under study. These guides are resolved individually prior to the face-to-face class in their homes or another place that each student considers appropriate.

3.2. Theoretical summaries

As an introductory activity to each face-to-face class, the teacher provides students with a brief theoretical summary in order to quickly return to the concepts covered during the week. It is understood that the students prior to the face-to-face class must have studied the theoretical concepts of the week at home or in another appropriate place.

3.3. Written support material

• At the Tecnológico de Costa Rica (TEC), various mathematics teachers have developed theoretical support materials for the different courses, for ours on differential equations there are five brochures by Sharay Meneses Rodríguez, MSc namely:

- First-order ordinary differential equations
- Application problems using differential equations
- Higher-order differential equations
- Vibratory motion problems
- Laplace transformed

The previous brochures have served as the basis for the student of the Differential Equations Department for years; however, in addition to them, they have been supplemented with other materials from other of our school's teachers.

- First Order Ordinary Differential Equations with interactive support and illustrative videos. (MSc. Norberto Oviedo Ugalde MSc, 2019)
- Differential Equations (Luis Alejandro Acuña Prado, Ana Marcela Rojas Loaiza, María Nazarelle Rojas Machado, 2019)

In the weekly orientations and in accordance with the provisions of the instructional design, the teacher assigns the students the sessions that are to be studies based on the materials previously mentioned.

3.4. Classroom exercise Videos

As a way of providing support on the various topics studied in the course, 46 videos on solved exercises are produced, in which detailed explanations of them are provided. In order to understand the videos, the learner is instructed to have previously studied the concepts discussed there, since some of the videos include exercises that are not so traditional or with a medium degree of difficulty.

During the process of the creation of the videos, as we had no experience in it, at the beginning, options such as recorders were tested through tablets with a pencil, which apart from having a high cost, was not appropriate in our case because I did not feel comfortable and handwriting was difficult, that is why in a first stage it is then chosen to carry out the exercises in Power Point presentations in which the resolution of the exercises can be presented in a more attractive and dynamic way. For the elaboration of the slide template, we had the support of a graphic designer from TEC, Ing. Luis Carlos Guzmán Arias, likewise the fingering and animation of the resolution processes of the exercises embodied in the presentations was overseen by the assistant from the School of Mathematics, Dayana Calderón Prado.

In the second stage, one proceeds to the review and pertinent adjustments to leave the suitable presentation of every exercise and without errors and then to proceed to the recording of the explanation of the presentation by means of a screen and audio capturer.

In a third stage, we proceed to look for appropriate screen recorders that feel comfortable and are appropriate to our needs. In our case, it began with recorders, such as Screen Record, Apowersoft, Screencasr-o-Matic, Debut, of which, the paid version of Debut is chosen because of its ease in adjustment and comfort.

In the fourth stage, once the first versions of the videos have been recorded, they were reviewed in terms of audio, editing errors and text, which is why, the video was edited and an assistant producer was used, Jonnathan Ramirez of TecDigital. In some cases, it goes to a second or third revision and editing to obtain the final product. In the final stage, REA forms are filled out in order to obtain a final review of the form and thus be published in the TEC repository through videos on YouTube to be shared by students in general. Some examples of video cover are shown in figure 1 and visualized through the links: `https://youtu.be/M-Kz91akjko`, `https://youtu.be/kGrPaa2esqM`.

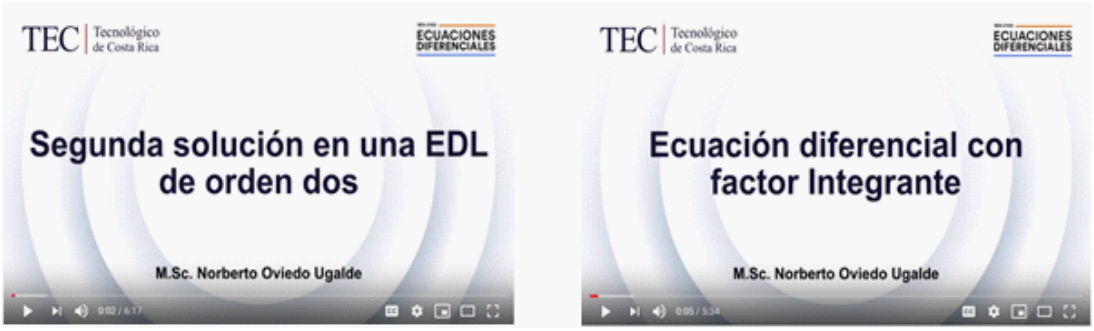

Fig. 1 Covers of videos developed in the semi-virtual course

3.5. Interactive notebooks using Mathematics software in CDF player form

For six years, I have worked with the non-free Mathematica software, through a license given to teachers from the University of Costa Rica, where I have worked in parallel with Tecnológico de Costa Rica during that time. As product of my graduate work in my Educative Mathematics Masters from the University of Costa Rica, I have created some interactive pages on my field of study in differential equations of the first order, where the student can interact and visualize, step by step, the involved processes of different ordinary equations of the first order (ED01).

Given, that the Tecnológico de Costa Rica does not possess the license for said Mathematic software, I begin by investigating how to use or readjust the pages that have been already worked on, in the free software. This is how, the free format of the Mathematica CDF software (Documents in computable format, freely downloadable from `https//www.wolfram.com/cdf-player/index.es.html?footerlang`), player, which offers the interactive and dynamic option of computable documents worked in Mathematica software in a free format. The respective adjustments and adjustments are made to the programming codes elaborated by means of the Mathematica software

and saved in CDF format until the pages or interactive notebooks of free access are made. For the differential equations semivirtual course, three interactive notebooks were divided in the following manner:

I. Interactive notebook on first-order ordinary differential equations (published in the TEC School of Mathematic magazine and can be viewed on `https://tecdigital.tec.ac.cr/revistamatematica/material_didactico/revisado/`

II. Interactive notebook on superior order linear, differential equations. (`https://tecdigital.tec.ac.cr/revistamatematica/material_didactico/revisado/`).

III. Interactive notebook on differential equations by Laplace transform. (`https://tecdigital.tec.ac.cr/revistamatematica/material_didactico/revisado/`).

Each interactive notebook comprises interactive pages on the different topics of interest, in which a brief theoretical summary (definitions, theorems and resolution processes) of the different topics to be studied is presented, along with predetermined and resolved examples in which the reader will be able to visualize his resolution process step by step in a dynamic and interactive way and serves as a support tool for the study of the topics presented there.

3.6. Evaluations online (quizzes) using GAAP

One form of online evaluation developed consists of the creation of virtual quizzes every two weeks on the different topics studied in them. To do this, a series of single-selection and false-true questions are drawn up and developed in Latex code (mathematical text editor), which later serve as the basis for the creation, programming and revision of virtual quizzes by means of the TEC's own platform through the learning activities manager of the same.

In general, the virtual quizzes consist of 5 single-choice questions that are worth 1 point each, where theoretical concepts are directly evaluated and two or three true or false questions where more concepts must be developed in order to give the correct answer. These quizzes are enabled online to students on weekends for a maximum of 12 hours, where once entered, there is no option to return and leave incomplete, meaning that each student must have previously studied the theoretical concepts. Once the virtual quiz has been completed, the student automatically receives the grade.

4. Course implementation

Once the materials and support resources described in the previous section have been developed and reviewed, we proceed to the implementation of what is embodied in the instructional design, that is, to put it into practice as planned. Since 2017 to the present, I have been teaching the differential equations course, in which as the various materials were developed, they were being implemented. I clarify that it was until the second half of 2019 that has been fully applied to a group under the semi virtual modality.

The Tecnológico de Costa Rica uses its own platform, TecDigital, where the course was developed and organized and presented in an orderly way, with week-by-week sections of course presentation, weekly orientations, information from the department chair, teaching materials, evaluations of GAAP tests and other documents that are used for the course. This serves as a means of information and teacher/student interaction. In figure 2, you can see a screenshot of the components of the TecDigital platform.

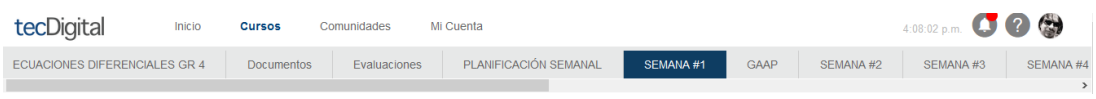

Fig. 2 Semi-virtual course portal group 04 of the I semester 2020

5. Aspectos evaluativos

The semi-virtual modality course carries out the same three partial exams of the other groups of the chair, which are theoretical and developmental in person in a classroom on non-teaching days. The three partials with a total value of 81% and a percentage weight of each of 27%. Furthermore, there will be a percentage of 19%, destined for

perhaps short, virtual evaluations every two weeks through the learning activities manager (GAAP) of TecDigital and tasks during the weeks that there is no virtual quiz.

Of a formative nature, in some weeks the student, prior to the face-to-face classes, will make didactic guides, and sometimes in the class, a contributory work in pairs on the weekly subject.

6. Results of the course evaluation tools

In order to learn about student information and also the appreciation and assessment of experience on the implementation of this semivirtual course, two questionnaires were applied:

I. Teacher questionnaire

It consists of a teacher's own questionnaire based on 15 closed questions in which it is first intended to know information about the group's students, such as whether they have repeated the course, weighted average enrollment, how many hours they dedicate to the course, etc., and others such as those shown in Figure 3 that allows direct appreciation of aspects of planning, organization and implementation of the course under this semi-virtual modality, which are important forms of feedback in order to improve.

13.	¿Con respecto a planteamiento y organización del curso en el portal del TEC digital, qué calificación le daría a este de curso de ecuaciones diferenciales bajo la modalidad semivirtual? ( ) muy mala ( ) mala ( ) buena ( ) muy buena
14.	¿ Los materiales de apoyo brindados como material escrito, videos, aplicaciones de software en CDF player, le beneficiaron y sirvieron de apoyo en el aprendizaje de los distintos contenidos del curso? ( ) nada ( ) aveces ( ) casi siempre ( ) siempre
15.	¿En términos generales qué calificación le daría a este de curso de ecuaciones diferenciales bajo la modalidad semivirtual? ( ) muy mala ( ) mala ( ) buena ( ) muy buena

Fig. 3 Semi virtual student appreciation questionnaire questions

With regard to results obtained by applying group instrument 09 of the second semester of 2019 where 30 students participated, in general they indicated, that average group age ranges from 20 to 23 years, only 1 work, two repeat courses, on average dedicate 4 to 6 hours to the course weekly, weighted average of average enrollment of 80 to 90. Questions 13, 14 and 15 in Figure 3 also have the following:

Question #13			**Question #14**			**Question #15**	
	Frecuency			Frecuency			Frecuency
Very bad	0		Very bad	0		Very bad	0
Bad	0		Bad	0		Bad	0
Good	7		Good	9		Good	10
Very good	23		Very good	21		Very good	20

The results obtained in these questions show a very good acceptance and assessment on the part of the students of the semi virtual modality course, that is, they consider there was a very good planning, organization of the course in the TecDigital portal, the materials provided (theoretical material, CDF player software applications and videos supported them and helped them learn the different topics studied in the course.

II. Course planning and portal questionnaire – generic

This questionnaire consists of an instrument with 9 closed questions on general student information, 32 closed questions on a Likert scale from 1 to 10, 1 being the lowest score and 10 the highest and 1 open question. The same is applied during week 14 by the person in charge of the project through the TecDigital in charge of Julia Espinoza, which has the objective of assessing these aspects: general student information, objectives, contents,

learning activities, educational and evaluation materials, everything related to the planification, organization and evaluation of the course portal. Below, there is a sample of the main results obtained from the 29 students who filled out the questionnaire are shown by means of tables uch as those shown in Figure 4.

Instructional Design Component	Average	Standard Deviation
Objectives	9.38	0.98
Contents	9.41	1.05
Contents	8.61	1.90
Support Materials	9.61	0.78
Evaluation of Learning	9.19	9.18
General Average	**9.18**	

QUESTION	Answer	
	Yes	No
When enrolling this course, did you know that it would be taught bimodally or semivirtually?	6	23
Based on your current experience in this course, would you take a course in this modality again?	26	3

QUESTION	Answer	
	Yes	No
Is the information structure of educational resources clear?	29	0
Was the amount of information (textual and graphic) provided in the educational resources sufficient to understand the topic?	28	1
Do the multimedia elements used give correct support to the didactic content?	29	0
Does the organization of the course portal allow easy navigation between its contents?	29	0
Does the course portal organization make it easy to locate available learning materials and resources?	28	1

Fig. 4 Main results obtained from the 29 students who filled out the questionnaire

Student comments (verbatim copy, no spell check):

- All very well, the only thing I don't like is the idea of only coming one day a week.
- As a suggestion more practice could be added.
- They should use a different evolution to the face-to-face courses, as in some of the CDI that the exams are worth 60.
- Complementing the semi-virtual modality with the teacher who taught the course makes the course simple thanks to the large amount of content available digitally and face-to-face classes.
- The CDF-player material is very good. Excellent service.

7. Conclusions-recommendations

1. Some resistance persists to this type of course modality.
2. Instructions in weekly guidance and platform should be timely.
3. Requires discipline on the part of the student to carry out step by step what is indicated in each week.
4. Strengthen evaluations in line with GAAP or other related evaluations.
5. To promote diverse, classroom activities for major interaction on behalf of the student.
6. Have a pdf in which you can share more quickly and directly what is captured on the TECdigital platform.

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