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Lessons in the Use of Technology for Science Education during COVID-19 Age under a Teachers' Collaboration Cluster

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Abstract: The COVID-19 confinement has represented both opportunities and losses for education. Rarely before has any other period moved the human spirit into such discipline or submission—depending on one's personal and emotional points of view. Both extremes have been widely influenced by external factors on each individual's life path. Education in the sciences and engineering has encountered more issues than other disciplines due to specialized mathematical handwriting, experimental demonstrations, abstract complexity, and lab practices. This work analyses three aspects of science education courses taught by university professors in a collaborative teacher cluster, sharing technology applications and education methodologies in science over three semesters when the COVID-19 lockdown was in effect. The first aspect was a didactic design coming from several educational frameworks through adoption or sharing. The second one was an analysis by discipline of multiple factors affecting student engagement during the health contingency. The third analysis examined the gains and losses in our students caused by the university closure and the pandemic's intrusions. The report explores the correlations of the exiting student perceptions with their academic performance in the courses and survey results about the impact of decisions or happenings during the crisis. This work's value lies in the lessons for the future of education concerning the teacher dominions of didactic design, support, and collaboration in a broader sense than only for teaching.

Keywords: scientific education; COVID-19; educative innovation; technologies; methodologies; higher education

1. Introduction

Global education has never been tested on the scale of the current COVID-19 pandemic. The health emergency forced massive confinements; overnight, it necessitated technological support to deliver education [1]. This complex experience has been lived differently in Mexico depending on the level and type of education, and was more benign in higher and private education. Even with ten years of development of mobile educational technologies, the diverse mastery of technology among teachers and students resulted in uneven and uncertain outcomes.

In addition, numerous concerns have arisen in the aftermath regarding behavioural issues, orderliness, and cognitive effects [2] resulting from the online educational support imposed by the most viable model to solve the crisis [3]. Other issues, yet unknown, undoubtedly will appear in the upcoming New Normal.

During the COVID-19 lockdown, our knowledge of online technologies and disruptive methodologies increased significantly through experimentation, offering better learning to students in the various educational levels [4]. However, many initiatives were first applied empirically, instead of from a well-planned theoretical framework. Still, not all was lost. In most cases, teachers increased their efforts to measure, assess, and improve their didactic designs to deliver the best possible learning experience. Teachers needed to draw up and devise a proper teaching plan considering the contents and the elements necessary for their students to attain learning.

In addition, in the online versions [5], new creative and flexible methods were developed to supersede the pressure and tedium of single, direct transitions from the face-to-face courses, empirically rediscovering many of the leading contemporary Learning Theories (LT). Thus, new tools and techniques had to be combined to offer more effective learning experiences in the lockdown period to solve urgent learning necessities and deficiencies. Lessons from this experience indicate that education in the New Normal will require a universal learning theory to the cover different needs and interests of learners.

This paper quantitatively analyses the diverse perceptions and learning impacts on science education due to the confinement at a higher education institution in Mexico. The task was afforded through methodological and technological strategies introduced in new didactic designs. The Section 2 briefly reviews LT to understand the reasons for the various implementations in the research. These are then linked to generic considerations of the design. Finally, this section provides a short contextual description of education in Mexico and the authors' institution during the outbreak period.

The general decisions relating to education during the COVID-19 confinement are discussed. Section 3 presents the research questions and objectives, design, data collection, and data analysis methods. An analysis of the participants, their demography, and the courses involved are also included. In Section 4, an analysis of the didactic design criteria for the implementations is introduced, along with their chronology. We also discuss the interdisciplinary decisions for the courses during the one-and-a-half years of emergency education sustained primarily online.

We compare the students' global perception about the implementations with the learning performance obtained in the same section with statistical correlations and meaningful dependence to arrive at lessons learned during the educational lockdown period. A representative compilation of the students' academic opportunities and losses during the confinement period is analysed. Section 5 discusses the findings, particularly some transversal behaviours and impact, success, and opportunities revealed. Section 6 sets out the conclusions of the report concerning the research objectives.

2. Theoretical Framework, Context, and Research Orientation

2.1. Theoretical Approaches to Learning

Everything we know about education has been tested during the COVID-19 confinement. Still, in the New Normal, education will undergo a deep analysis of its conceptualization and operability to foresee its future and evaluate its past losses. During the pandemic, academicians have had a prime time window to experiment and understand the future of education and their moral duty during this challenging period for humankind [6].

The teaching and learning process is commonly constructed by teachers and students from experience; there are guidelines supported by learning programs, teacher training, and strategies and trends settled through proposals in textbooks. However, all of these are generic. Most students and teachers are not exposed to education theories that consider how students learn [7]. Currently, it is almost universally recognized that the five main education theories cover most practical education scenarios.

Still, during the confinement, the various educational areas were guided by relevant education theories developed in recent decades by disciplinary academicians and theorists and supported by the most affordable learning methodologies commonly used in each one [8]. Nevertheless, in most cases, a guide was not first planned; instead, educators assumed that the inherited daily practices could be simply adapted from traditional face-to-face teaching to the online modality. From our viewpoint, understanding the distinction of planning the guidance was one of the critical factors of the success or failure of education during the COVID-19 confinement.

Possibly, most teaching practices are influenced by the traditional Cognitive Learning Theory (CGLT), which succinctly states that learning practices should be designed according to the learner's style of thinking, which is still influenced by internal and external factors [9,10]. Thus, for cognitive learning theorists and practitioners, the various stimuli and learning spaces occurring in the classrooms are essential for diverse audience learning. Such catalysts in the form of activities and contents based on diverse learning styles flood the teaching-learning operative scenario in most contemporary classrooms worldwide.

Another trend with a more critical eye is Behavioural Learning Theory (BLT), which suggests that learners act based on their interactions with their environment and community; thus, if the contents do not reflect a practical immediate utility in their daily lives, it is meaningless [11,12]. Constructivist Learning Theory (CNLT) assumes that knowledge is constructed through steps combining previous knowledge and additional experiences; thus, each learner has a unique reality based on their prior learning experiences to support their attainment of new knowledge [13].

In this practice, activities are thoughtfully designed based on previous assumed knowledge to create new learning experiences. Then, Humanistic Learning Theory (HLT) follows and modifies the last two approaches, stating that, although knowledge is constructed from previous experience, it responds to the environment; the learner prioritizes specific learning according to their interests and needs [14–16].

Finally, Connective Learning Theory (CCLT), the newest theory, attempts to reshape the previous inputs, stating that learners are moved to learn by the overall connections in their lives, linking the past, needs, people, hobbies, and duties, among others [17]. Thus, motivation is an essential element in this approach, and is derived from several diversified inputs. Those inputs in this contemporary learning theory, not always explicitly and exclusively indicated, refer to the internet connections pervasively surrounding and immersing the learner in the 21st century. This approach naturally introduces technology in education as a necessity in most aspects of our modern life.

2.2. Didactic Design in Hybrid Online Approaches

Teaching techniques and practices are elements of LT that provide instructional structure; the learning elements or objects improve learning. Unfortunately, mainly in the upper levels of education where teachers have an informal teacher training, these are often seen as unrelated to the theoretical approaches. However, it is important to remember the background in which they were applied [18].

During the COVID-19 confinement, such techniques were moved from the classroom to the videoconferencing sessions without clearly understanding their utility and purpose in a different learning environment having other characteristics. Thus, technologies, methodologies, collaboration, and social learning were not sufficiently attended to or included in the transition as elements of a broader view of education.

Thus far, the design and organization of the school and classroom environment attend to deep learning motivations, many of them markedly altered by the pandemic [19]. Education during the COVID-19 confinement has been directed by new rules. In an uncertain environment, students have strived to learn while immersed in a diversity of places, spaces, and times that boost distractions. They have to share additional family routines or work activities that work against their learning activities. Since the beginning, diverse personal scenarios have disadvantaged certain students [20], leading to poor learning performances.

Additionally, the didactic designs have not included optimal adaptations of the crucial elements in learning activities stated in the education theories previously discussed [21]. Such real learning situations have promoted the opportunity to retake education using BLT and HLT approaches [6]. The didactic designs for distance learning must employ methodologies that include relevant technologies and organization. They are part of a broader global educational strategy pursuing specific long-term objectives aligned with interests particular to different learning scenarios.

CGLT has historically settled the traditional, modern education practices, thus, translating theory into action [22]. It involves instructional design and learning designs. In recent decades, the rise of emerging technologies and their educational applications have led to alternative approaches that immerse learners in a world of information. Thus, the transition from CGLT to CCLT has been happening in recent years [23].

The COVID19 confinements accelerated emerging Information and Communication Technologies to overcome the possibility of education closures forced by the pandemic. The hybrid approaches became entirely online with videoconferencing. Before the pandemic, CCLT was broadly contrasted as a learning theory against approaches, such as CNLT, BLT, and HLT [24]. In any case, all learning theories previously mentioned are active, and all of them have provided valuable contributions to education during the COVID-19 confinement through teaching methodology proposals.

Whether based on CCLT or not, technologies have been necessary to support student learning in various ways. The methodologies must be scaffolded using adequate technological tools to reproduce or improve the face-to-face experience. The technologies and methods became inseparable during the online approach. Worldwide, teachers and learners who were not provided with technological skills and clear guidelines for working in online environments in different learning scenarios were isolated [25]. Nevertheless, the changes presented opportunities and dictated social duties for the present and the future of education.

The rapid transition soon hit another critical element, the social impact of sustaining such demanding changes [26]. The low support to teachers from educational institutions quickly left them feeling alone with different teaching tasks and unable to meet the challenge [27]. Students, suddenly separated from their peers, had similar perceptions of isolation and unfamiliar educational modalities.

Despite frameworks for online learning including social constructivism [28], their pre-pandemic considerations became ineffective. Thus, deliberate social learning and collaboration become essential design elements in the teaching models for distance or inclusively online learning that are unique and urgent for education during the pandemic. At least three components should be considered in the emergency didactic designs during the COVID-19 confinement: methodology, technology, and social collaboration. Despite this, many teachers' lesson plans lacked these due to the hurry and lack of support and training as the crisis unfolded [29].

2.3. Academic Context Involving the Research Experience

The temporary suspension of classes in the authors' institution was announced on 16 March 2020, and became extended for one year and a half. The institution has more than thirty campuses throughout Mexico. The initial class suspension only allowed one week to prepare for the transition, which was, at first, expected to last only a couple of months. The institution's faculty was able to prepare in such a short time due to their regular use of Learning Management Systems (LMS) for more than two decades and a permanent training program in educational technologies for teachers [30].

Thus, the institution rapidly set up a plan to deliver all courses. The classes resumed through Zoom videoconferencing almost immediately, aiming for a hybrid experience to replace the face-to-face one. Thus, the transition proceeded less drastically than in many places. This strategy was shared with other higher education institutions during the contingency [31], helping them maintain their educational continuity during the lockdown. Videoconferencing and Online Learning were the most universal methods adopted by the international academic communities to replace face-to-face education [3,32].

Such sudden transition still put many students at a disadvantage if they had problems with internet accessibility, personal computer affordability, and the discipline to follow the online activities, among other things [33].

The Zoom videoconferencing tool and the existing institutional LMS tool (CANVAS) helped teachers in the transition to prepare suitable materials for the online approach, including the technological tools and the appropriate teaching methodology [34], and the teaching design outline [35] under the framework of Online Learning [28].

The lockdown led to strengthened, evolved designs with considerable improvements for the future of education [36]. All should be documented as a learning experience in global education [37]. Each local effort in this global challenge should be considered in education paradigms, not only as a response to the pandemic [38]. Thus, they should be considered, analysed, and assessed under the eye of formal learning approaches. This aspect is discussed below in the presentation of the didactic designs.

The period of confinement has reconfigured all the educational approaches, expanding our knowledge about tools and methodologies, allowing us to test their weaknesses, and discovering creative ways to deliver them [4]. However, during the implementation process, many undocumented and unexpected aspects of Blended Learning (BL) and the remote use of complementary technologies and methodologies became evident in student behaviour, mainly due to the extended periods of exposure [2,39].

Such discoveries promoted the modification of educational policies [40]. This aspect should be considered in more detail: the closure of schools followed by sudden and changed academic continuity was based on a series of assumptions not always fulfilled [21]. Observations and opportunities became evident not only in the current emerging model but also in reconsidering the face-to-face model and its gaps and deficiencies [41]. The response to these has been limited [42] to not disrupt education.

In the following sections, we highlight designs and considerations for science education arising in the light of learning approaches during the COVID-19 confinement and outcomes in performance, opinions, and student behaviour noted in the great diversity of courses and practices included in the report.

Finally, we declare certain research limitations. Our study was limited to a segment of science and engineering program students mostly living in urban areas and mainly devoted to study (some needed to work or help with family issues). For the most part, these students had easy internet access without connectivity and resource problems. Our discussion centers on the transition to learning practices inheriting characteristics from cognitive and connectivist blended approaches, the most common situation in our university community, without diminishing the casual presence of other LT contributions.

3. Materials and Methods

3.1. Research Interests, Questions, and Objectives

In this report, we inquire about the chronological evolution of BL approaches in university science courses during the COVID-19 lockdown, asking their impact, particularly as perceived by the students collaborating with a group of teachers. The general objective of this report is to analyse the development of innovations and the technological and methodological implementations from March 2020 to June 2021 within a collaborative teaching cluster in a higher education Institution in three of our largest campuses, particularly as the efforts were perceived by the students.

Mainly, we focus on: (a) analysing the evolution of the designs and implementations of the emergency didactics; (b) identifying lessons derived from the growing distinctions among the didactic designs and their possible extension to behavioural considerations of the students; (c) conducting an analytical and weighted comparison of the courses' implementations through the students' feedback in terms of parameters, such as related areas, class sizes, periods, semesters, general grades, and performance dispersion; and (d) summarizing pending tasks for the education of our students, considering their gains and losses during the closure and confinement.

3.2. Research Design

A collaborative teachers' group was formed to partner in scientific research to share and improve their academic duties during the COVID-19 lockdown, considering their teaching experiences and innovations since the pandemic's beginning. All the teachers involved teach science courses (math, statistics, physics, and some engineering science courses) in the same institutional programs but in three different campuses with similar urban characteristics.

Despite courses being assigned by the department chairmen on each campus through the three semesters of extended confinement, classes were taught following common directives developed from shared recommendations about methodologies and technology. The teachers' collaboration brought to light the emotional status of the students and the impact on their academic performance.

With three semesters of academic work under confinement, the collaboration group decided to analyse the data to account for (in the sense of [6]) the learning performance resulting from the instructional actions, particularly from the students' perspective. The latter was interesting and always correlated with the hard outcome data derived from the course evaluations. The courses were quite diverse in contents, period, area, type of innovation, and extension. Thus, the analysis began to arrive at standard characteristic parameters.

The group noticed that collaboration resulted in consensual decisions and didactic designs, first in terms of three main, flexible innovation streams of LT (particularly CCTL): Methodology, Technology, and Evaluation [40]), as appeared in many other international designs [3,4,43]. Soon, flexible assessment became common in our courses; therefore, such an approach does not particularly highlight innovative designs [34]. Those elements were evident to transit from a CGLT style (where the social learning component is barely but naturally present in face-to-face instruction) to a CCLT style [44]. In the first academic semester, it became evident that social learning and collaboration in the online designs were missing.

This needed to be modified considering not only the methods and technology but also explicit learning spaces to sustain learning input more oriented to HLT and BLT statements [15]. Then, highlighted elements inherited from CCLT approaches (methodologies and technology) became complemented by deliberated techniques to introduce collaborative and social learning continuously, in terms of CCLT directives [17,44] and, particularly, the Online Learning framework [28].

Thus, the collaborative cluster decided on a research design through comparative common theoretical design elements [15,28,40,43] in their overall experiences, highlighting didactics that considered methodology, technology, collaborative networks, and flexible assessment. These primary components were then tracked during implementation and analysed for concrete methodological, technical, procedural, and technological elements. The research was set from the beginning to be quantitative and consider the primary elements useful for an analytical comparison with student perception: the general final grades, descriptors, and the registers of students' opinions.

As final grades alone do not describe the overall impact of a strategy, we decided to include the student perception of the teaching process. Thus, despite being limited, it was an interesting analytical input regarding the teaching performance in each course because it looks at academic achievement with a vital strength [45]. Student input is meaningful and essential to improve courses by evaluating the teacher's delivery and the educational methods employed in each. This indicator has been used in similar analyses to quantify the courses' impact on academic implementations during the COVID-19 outbreak [46,47].

For our institution, despite several questions included in the exit survey, we decided to consider only the final question, accounting and summarizing the previous ones in terms of the overall recommendation about the learning performance in the teacher's course. Such a final question is only established after a series of reflections on course quality, mastery, accompaniment, support, continuous evaluation, and methodology, to improve the final assessment.

As we were interested in the overall emotional aspects affecting students' academic lives [29] during the three semesters included in this report, we applied an additional final survey to a subset of randomly selected students (5% from one of the classes in the third period of the confinement). This subset included students previously enrolled in at least one more course within the teachers' cluster. This survey only enquired about the academic opportunities and losses each felt due to the confinement. Table 1 summarizes the research design in terms of the inputs to be analysed.

Table 1. Research designs in terms of demography, indicators, and data subsets classification.

Demography	Course	Final Grade	Recommendation	Final Survey
Group size Campus	Area Course Period Innovation Semester	Average Std. Dev.	Average Std. Dev.	Main opportunity Main loss

3.3. Courses Involved, Participants, and Their Demography

The first input was the register of the courses involved in the analysis. We considered 66 courses in three semesters or academic periods: February–June 2020 (FJ20), August–December 2020 (AD20), and February–June 2021 (FJ21). Due to the diversity of the courses, we grouped them in three natural content areas: Math and Statistics (MS), Numerical Methods and Simulation (NM), and Physics and Engineering Sciences (PE). That information is summarized in Table 2. Course topics included calculus, mathematical modelling, and differential equations in MS; numerical methods, computational physics, and simulation in NM; and Kinematics, Mechanics, Electromagnetism, and Experimental Physics in PE.

Table 2. Demography in terms of groups and students classified by semester and academic area.

Demography	FJ20		AD20		FJ21		Total	
Area/Size	**Grps.**	**Stud.**	**Grps.**	**Stud.**	**Grps.**	**Stud.**	**Grps.**	**Stud.**
MS	0	0	5	144	0	0	5	144
NM	7	196	4	122	6	195	17	513
PE	0	0	23	644	21	590	44	1234
Total	7	196	32	910	27	785	66	1891

The data show few students and a poor representation during the first and third periods for Math and Statistics; most of the students were concentrated in the two other areas considered in the report. This could be a study limitation. The courses were taught by teachers in a collaborative learning cluster to implement new technologies and methodologies. Each student in each class was considered a student-course, meaning that each could count several times if in several of their courses they were involved in specific learning activities or cluster courses.

Additionally, most of the classes depicted here were operating under the Tec 21 Educational Model [48], with courses lasting one, two, or three five-week periods within the semester. The students attended three different campuses, one in the country's north (MTY, Monterrey) and the others in the Mexico City area (CEM, Estado de Mexico, and CSF, Santa Fe).

Most of the students in the study were in the first two semesters of engineering programs, which was significant in the conclusions because those students have taken their university studies entirely online (see Table 3). The analysis could be meaningfully extended from the third to fourth semester. Students from the first and second semesters covered shared curricula and those from the third to fourth semesters.

Table 3. Demography in terms of campus and program semester.

Campus/Semester	1st	2nd	3rd	4th	5th	6th	7th	8th	Total
MTY	246	462	20	70	0	0	4	4	806
CEM	115	115	0	50	0	0	0	0	280
CSF	280	322	118	85	0	0	0	0	805
Total	641	899	138	205	0	0	4	4	1891

3.4. Data Collection Methods

Each course design required a specific teaching plan involving tools and methodologies despite certain similitudes in the same academic field. A detailed registration of technologies, methods, and motivations was established to account for each intervention's additional under a chronological and methodological comparison. To measure a comparative learning impact, we considered the final grades for each student together with a synthetic quantitative evaluation of the teacher's work as opined by each student, using a standardized institutional exit survey applied in each course.

This allowed us to assess the students' engaged learning impact compared with their final grades in the study population classes, a terminal measure of their performance. The raw data used for the central part of the analysis are reported in Appendix A.

The information in Appendix A was grouped into categories and compared to fulfil some research objectives; the primary variable was the student's opinion of the designs, teacher effort, and educational elements. Some differences among the three campus populations are noteworthy. CSF historically has had a more demanding student perception concerning the course quality compared with MTY and CEM, even though the contents of each course are the same on the different campuses of our university system.

Most of the classes have the same pre-built structure of CANVAS courses, which are cloned and delivered to each teacher to personalize them. The COVID-19 lockdown has led to a closer teacher collaboration among the faraway campuses more than any previous time as the authors sustained permanent communication, collaboration, and outcome sharing. The resulting product is this study, reporting the main findings from the common sharing of diverse courses. The collaborations demonstrated practical and fast dissemination of teaching practices [49].

The data was gathered during the three semesters encompassing the implementation of specific guidelines of the Hyperflex distance learning model [34], which covered the technologies, methodologies, policies, and protocols across our institution during those three semesters of confinement. In addition, the teachers' close cluster membership led to faster implementations as the recommendations and experiences from each member could be adopted. Demography, course, final grade, and recommendation data were provided by each teacher without more details than the entries mentioned in Table 1, except for the statistical distribution of the teacher's assessment in each class, which was also provided by each teacher (by design, it does not contain a reference to the students).

Additionally, to obtain information about the behavioural aspects of our students during the outbreak, we analysed the outcomes of an additional survey applied randomly only to the 5% of students during the last period, as explained previously. We summarized their perceptions of the most significant academic or personal gains and losses during the three semesters involving the COVID-19 lockdown. Each student had to have taken a previous course from at least one teacher of the cluster. This final survey was coordinated by the research group; it never asked the participant's name despite requiring the authentication of the student responding. Written opinions were grouped by affinity in no more than twelve similar issues.

In terms of the ethical issues, all the analysis information does not include personal data. All teacher and student information was anonymous and represented under central tendency or dispersion measures (as in Appendix A).

3.5. Data Analysis

Data analysis was conducted using techniques aligned with underlying interests. For the overall analysis of the global implementation, we classified the courses by areas and identified the date each methodological or technological implementation introduced for the first time through the three periods (such elements remained in subsequent associated courses). Thus, we softened the implementation data using mathematical modelling for the continuous growth of the teachers' mastery of the innovations (instead of attempting a complete and efficient implementation in only one step).

The final grades were analysed with the recommendation outcomes by course (for statistical measures, average, and standard deviation), combining and including the metadata for a factorial analysis afterwards to validate statistical tests, as required. Despite an overall model of significance first obtained with the most correlated variables or factors, we carried out a single correlation model to reveal direct and more comprehensible one-to-one correlations [50]. The student perception was analysed as a final measure of positiveness or negativity, and the possible causal factors were always considered.

Finally, to complement the accounting for the student's academic performance, we examined the data about the more significant educational goals or losses during the three semesters of the confinement. Interestingly, in most cases, those facts are related to the course implementation and contact with the teachers and peers, surely promoted by the teachers' deliberate collaboration in the didactic designs. Note that the students were freshmen and sophomores, and the courses analysed were the main ones in their academic programs in those periods.

4. Results and Analysis

In this section, we first depict the generic course design for the comprehensive set of courses and areas and then account for the chronological development of the innovations. Such analysis evaluates the collaborative performance of the teachers in the cluster; further analysis could provide complementary information about each of the three semesters in the study period. Next, we report the outcomes and immediate analysis and cover the research questions and objectives established beforehand. Finally, a more profound discussion in the next section mainly attends to certain factors and specific considerations related to each objective.

4.1. Course Design and the Implementation Enrichment Imposed by the COVID-19 Confinement

Every course in March 2020 went through a transition—a redesign process imposing the video class as the primary resource of contact and the institutional CANVAS learning management system for plan adaptations. Each course was unique per the content requirements.

The designs implemented by each teacher included a teaching lab that was continuously modified [36] and followed the CCLT and Online Learning framework as previously established [17,28] but considered some design elements from BLT and HLT [14,15]. To prepare for our first research objective, we classified design decisions, particularly comparing the disruptive features under the hybrid version during the COVID-19 confinement versus traditional face-to-face teaching.

The first transition at the beginning of confinement in March 2020 showed that design categories to be considered should be extended in comparison with the corresponding traditional face-to-face course. Still, it already had some BL elements. Thus, during the suspension week, all the classes became hybrid to a lesser or greater degree depending on the available electronic resources and activities considered [51] and the videoconferencing presence to which the face-to-face component shifted.

Figure 1 shows graphs exhibiting the transition (left to right), crossing from few elements (red lines) in each category (green lines) for most of the courses in the traditional face-to-face design (left graph) to the more complex design (right side). The transition included additional constructions, including evaluation, mandatory technologies, video classes, and other critical course elements. Methodologies explicitly had to have stimulating variations during the class sessions [17,28] in agreement with CCLT.

Finally, designs needed to incorporate contact among the teachers and students to facilitate collaboration and social learning [15,28]. Thus, new focuses were on teaching, stimulus, presence, accompaniment, and assessment compared with face-to-face versions [8] or still hybrid versions with that component (instead of the hybrid approach conducted by videoconferencing).

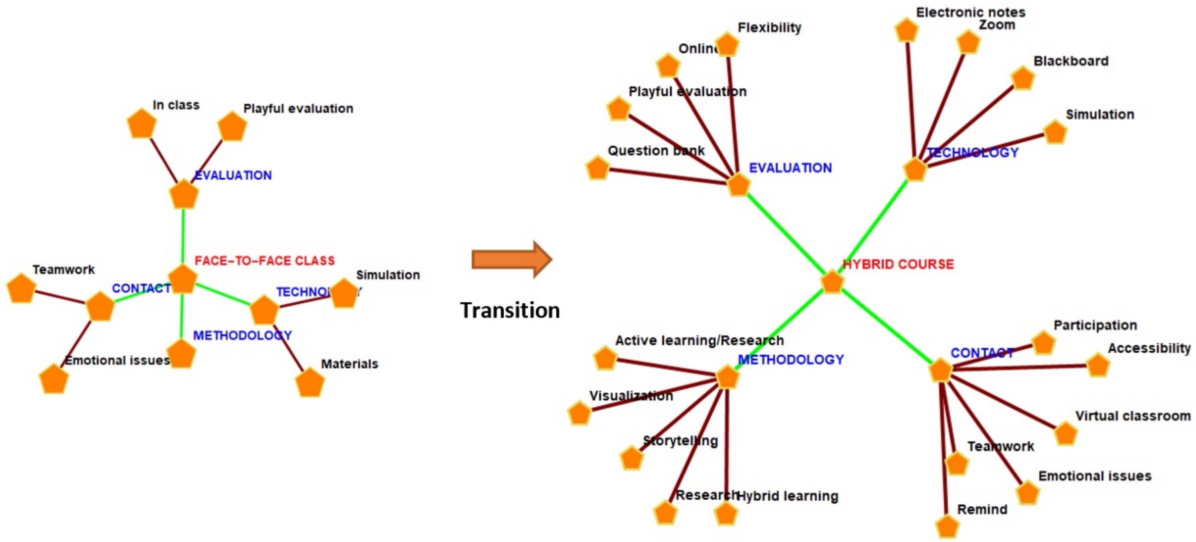

Figure 1. Graphs showing the transition of main design categories (blue) and elements (black) between face-to-face courses (red) and their hybrid versions during the lockdown. Labels are aligned to the left of each vertex.

Face-to-face designs should consider additional constructions (Figure 1 on the right). For instance, for evaluation, with some of them as a part of playful evaluations as part of the teaching plan. Question banks should be prepared to avoid fraud despite some required flexibility instead of the direct transition on a face-to-face evaluation sustained through videoconference. Particularly in Math and Physics, the necessity of fluid mathematical writing in technologies involving tablets and electronic pencils substituted for the blackboard.

Some easy tools, such as Excel, Mathematica, and Matlab, supplied the possibility to construct demonstrations and visualizations, or still simulations in the more specialized cases. After the first week of videoconferences, most of the teachers learned that flat classes based on writing as in the face-to-face approach were not very convenient. Thus, they introduced learning methodologies, some of them supported by technology.

Another important aspect was the necessity to promote interactions not only among teacher and student but also among students as partners. Social learning was probably one of the most endangered elements during the pandemic [39], and thus additional effort should be provided to avoid such loss, particularly in some courses where complexity and diversity became extreme [52].

Thus, despite a well-prepared faculty in online technologies [30], a sustained videoconference online class required new distinctions in the design. First, as was previously mentioned, for further analysis, courses were conveniently grouped by affinity in the three academic areas previously mentioned. A design in layers in agreement with the outstanding dimensions in CCLT let to classify most of the elements involved. Such layers are considered in the first level the learning networks in each course.

This included contact as well as activities considering the social learning among partners. The second level considered some adequate learning methodologies fulfiling the necessities of the first layer and concrete course requirements. Such methodologies then implemented social learning but directed to the necessities of each course.

Finally, the third level took account of the technologies and tools required to scaffold the other two first layers as well as the course orientation and specific technologies required by the professional practice. That structure is shown in Figure 2 where each main technology appoints to elements considered in the design, each one allocated in transverse layers. In addition, each academic area had differentiated elements according to their own necessities [35].

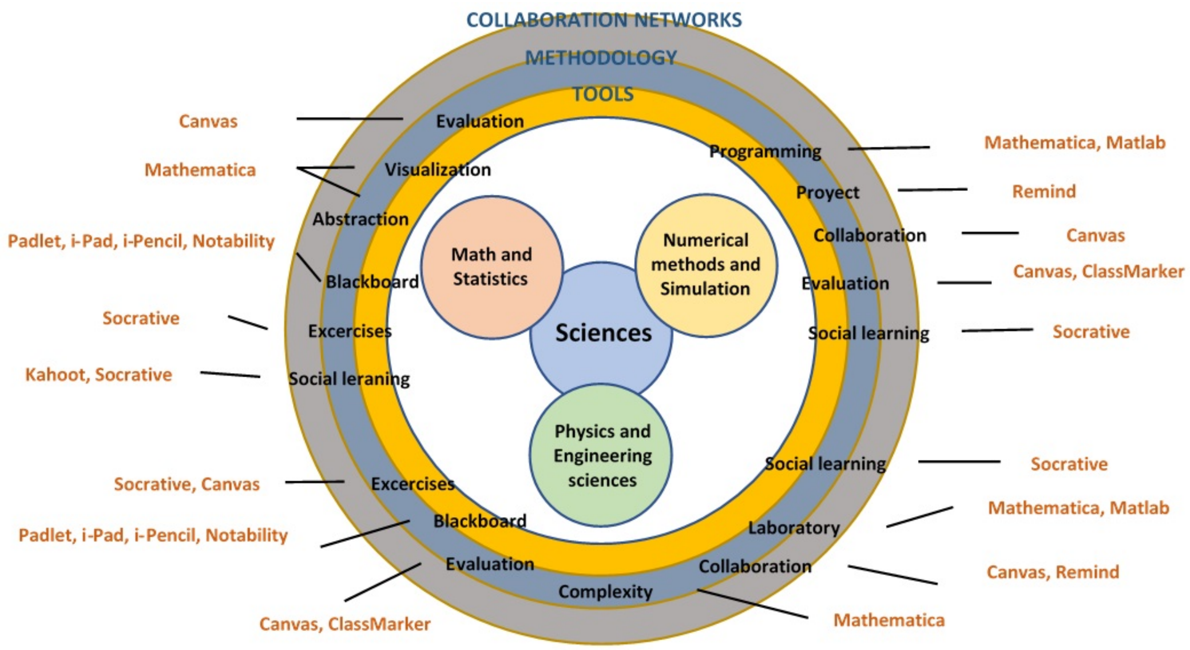

Figure 2. Courses areas in the Sciences department with teaching-learning elements allocated on three layers denoting the necessary tools, methodologies, and collaborative student's networks. Each element points to the technologies supporting them.

At the end of the first semester, the cluster noticed that additional complexity elements should appear. In a first approximation based on an Online Learning framework [28], poor considerations about the extended and sustained videoconferencing learning were made.

Behavioural issues were not originally considered or assumed in the didactic design. Soon, collateral relations among some elements (not shown in the graphs on Figure 1) became evident. Some of them are now shown in the graphs depicted in Figure 3 (gray edges). Thus, for instance, Zoom videoconference system could promote teamwork and participation considering some of its functionalities. A virtual classroom construction was convenient in each course to gather in a single document of the LMS the mobility among activities, class, plans, homework, and supporting resources.

However, this was not only convenient, this also allowed the flexibility and affordability of the entire course to support each student. As well, some other tools or technologies could play multiple roles in the course: visualization, Active Learning, etc. [36,53].

With those distinctions on the design, which were common elements of classification inside the cluster, no matter if courses belong to any of each one of the academic areas, each course was evolving through the three periods, considering a growing or a better group of methodologies and technologies [53]. In the following section, a quantitative analysis of the general implementations is given. Implementations were recovered from the daily course' documentation. This was followed by an analysis of the students' outcomes compared with their perceptions about the teaching-learning plan.

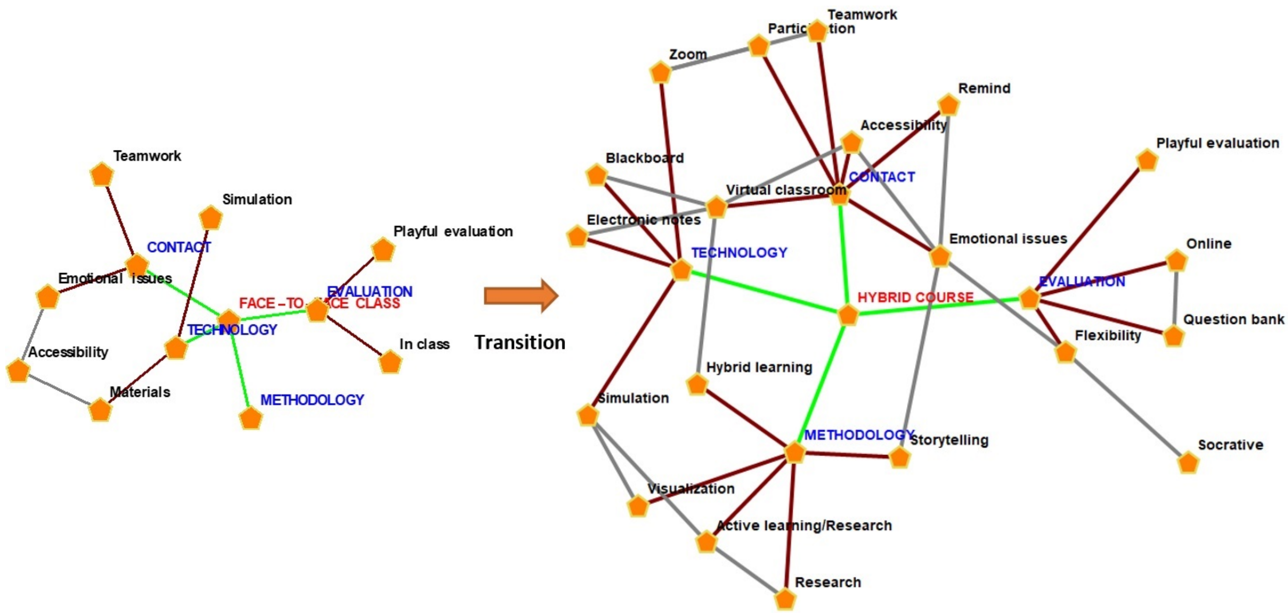

Figure 3. Evolved graphs shown the transition of main design categories (blue), elements (black), and inner associations (gray edges) between face-to-face courses (red) towards their hybrid versions during the lockdown. Labels are aligned on the left on each vertex.

4.2. Implementation Chronology, Development, and Categorization by Academic Area and Didactic Group

To fulfil the first objective of the research, we begin our analysis depicting the global process of inclusion of methodologies and technologies in the current subsection. At the beginning of lockdown, some methodologies and technologies were suggested by the training program in technologies approximately in terms of Figure 1 in agreement with the activity records in CANVAS. In general terms, apart from Zoom and CANVAS, other technologies were suggested for sciences and engineering: Remind as contact media and software like Mathematica, Matlab, and Geogebra for visualization.

While the semester advanced, some other technologies and methodologies were shared and introduced by teachers. In the teachers' cluster being depicted here, a near collaboration in terms of procedures, outcomes, necessities, and implementation recommendations was permanently sustained, thus, conforming to a learning community. Thus, through the three semesters, different methodologies appeared in the different courses to fulfil certain requirements or necessities demanded by each one in the different academic areas to provide increased opportunities for success in learning.

Figure 4 shows a detailed analysis and depiction of those methodologies and technologies as they were introduced for the first time in each area. Then, each technology permeated in other curses and inclusively areas, through the dissemination in the teachers' cluster. The plot depicts the months from February 2020 (the month when the first period of lockdown began) to June 2021 (the end of the third period, before the writing of the current report and the advent of New Normal for education in Mexico).

Orange lines state the end of each semester while black lines state the beginnings. Each academic area is depicted with different colours: MD in blue, NM in red, and PE in green. There, technologies implemented for the first time are remarked above and methodologies below. Each group of methodologies and technologies are grouped by affinity and they appoint to each academic area when they were first introduced.

The numbers in circles report the total number of estimated students in each group of methodologies and technologies impacted using them (such estimation was consistently obtained from the posterior register of such methodology or technology in CANVAS). The lower plot summarizes the softened continuous implementation process by a gradual model of increasing by monthly periods, which provides a perspective of the real progressive impact.

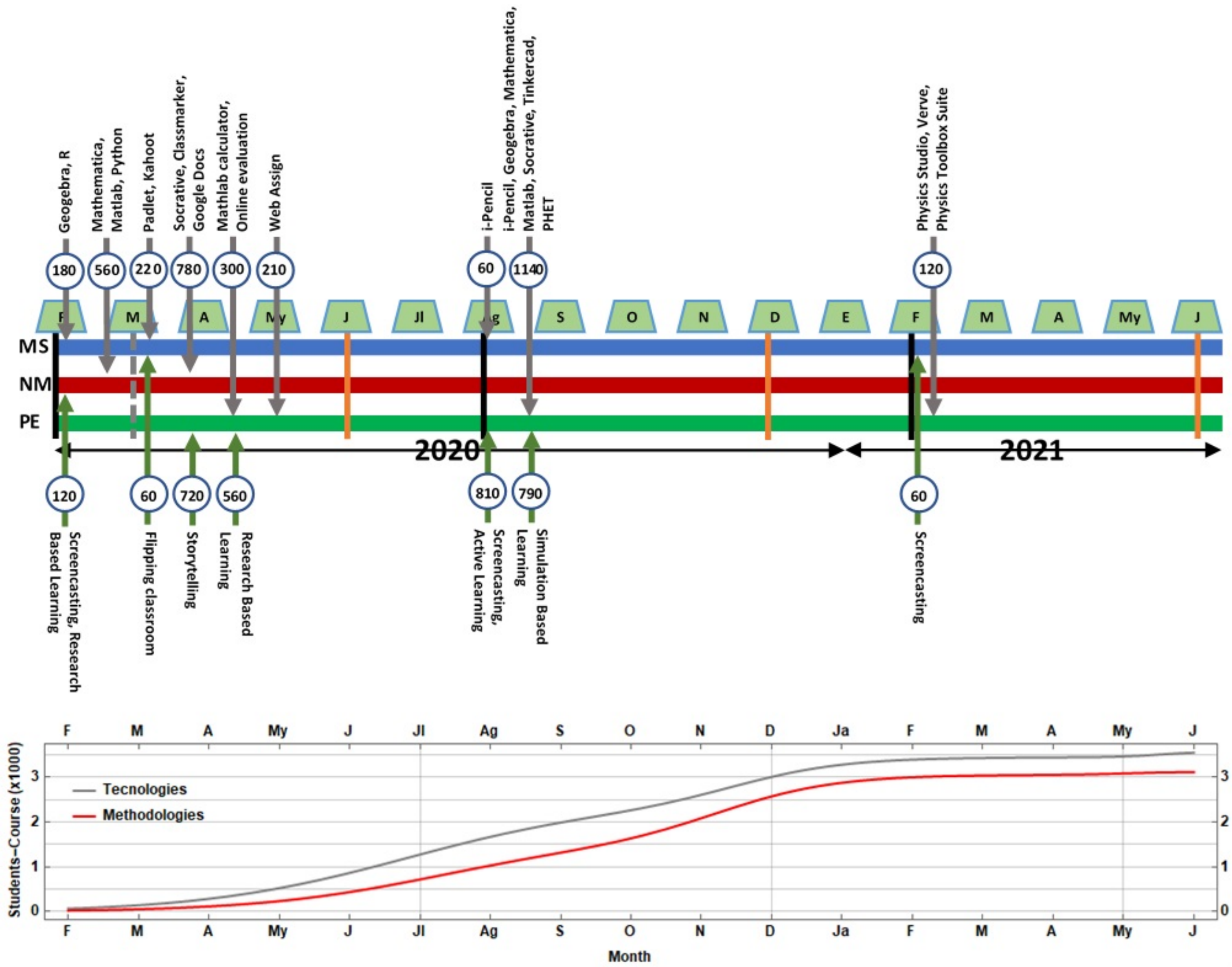

Figure 4. Chronology of the technologies and methodologies implementation in each area. Each arrow sets the beginning with each technology or methodology in some course, and thus transferred into others in the same period of another after. Numbers depict the total number of students/course impacted. The plot in the bottom reflects a softened curve of estimation for the entire technologies and methodologies during the lockdown period covered by this report.

ME required a fluent way to present and share mathematical writing and diagrams, which were neither easy nor convenient to present on pre-built slides. Thus, tools, such as Padlet or i-Pencil, were gradually integrated; however, they did not arrive before going through more traditional experiences of physical writing on traditional whiteboards, handwriting, or inverted writing in transparent crystals during the first weeks of videoconferencing (some of them affordable in Zoom).

Otherwise, the Screencasting resources also allowed to extend the number of exercises seen in class. Additionally, tools such Excel, R, Mathematica, and Geogebra were included to support visualization in Math. Individual and continuous practices were given through tools, such as Kahoot and Socrative additionally promoting social learning as well as motivation. Those tools supported mainly the Flipping classroom methodology, a technique to allow a more recurrent social practice of learning during the class.

For MN, although there were courses that, by their nature, previously had a greater digital development (due to their BL focus) before the existence of the Hyperflex model versions, the concept of the virtual classroom was still implemented as in other areas (the concentrator map of activities guiding the entire course activities and their navigation). The students appreciated this type of space as easier to understand those procedural and methodological aspects expected in the transition.

There, tools, such as Phyton, Mathematica, and Matlab, settled the basic support, and the slideshow facilitated the concentration of the specific theoretical developments before each numerical or technical method was reviewed in the courses. Support for the programming component continued being delivered through Screencasting in addition to the videoclass, which already existed in many of the previous courses.

FE represents most of the courses that were analysed in the current report. They faced two aspects: experimentation and complexity. For the first aspect, some experiments with homemade materials and directions given through Screencasting were implemented. Additionally, different simulation tools ranging from Geogebra, Physics Studio, Tinkercad, and Verve were used, and even programming to connect the real experience of the phenomena with the theoretical components of the courses [54].

Tools, such as the Physics Toolbox Suite allowed experimental measurements of motion, acceleration, magnetic field, etc., by using the mobiles of students [55]. This app supplied some measuring devices or provided alternatives for measurement. The aspects of complexity were partly addressed first with a planned visualization using Mathematica and Matlab, and then with the realization of a simulation project. The use of Mathlab calculator, a useful app for mobiles, made it possible to effectively resume the use of the scientific calculator with editing, thus supporting students in its use with a minimum of mistakes and waste of time during the videoclass.

Methodologies, such as Flipping classroom, Active learning, and Exercise solving, were implemented through tools, such as Socrative to generate playful spaces of collaboration on which social learning was reached. This practice became useful to bring closer to the students into the formal summative evaluations. As in MS, Screencasting also allowed to extend the number of exercises seen in class, this practice was inherited from experiences in NM. The use of Storytelling and its combination with animated slideshows or including demonstrative videos were useful to capture the attention in those courses.

As a general practice, in some courses, the advisory was recorded to increase the flexibility and the broadcasting to other students. A large bank of questions, to sustain remote evaluation letting several attempts, was implemented in tools, such as ClassMarker and Canvas. This allowed students complete their learning while obtaining improved grades. To summarize specific technologies and methodologies used in each academic area in terms of the main use, Table 4 presents that information.

Table 4. Technologies and methodologies compilation with their main use.

Resources	Videoconferencing	Advisory	Contact	Visualization	Writing	Evaluation	Social learning	Demonstration	Practicing	Experimentation	Calculation
Methodologies											
Flipping classroom						×	×				
Active learning							×	×		×	
Exercise solving						×	×		×		×
Research based learning					×		×				
Storytelling	×			×		×			×		
Simulation based learning				×		×	×	×	×	×	
Screencasting		×		×		×		×			×
Technologies											
Zoom	×	×					×		×		
Remind		×	×				×				
CANVAS	×	×	×			×	×				
Mathematica	×	×		×	×	×	×	×	×		×
Excel	×	×		×		×	×	×	×	×	×
Matlab	×			×		×	×	×	×	×	
Geogebra	×	×		×		×	×	×	×		×
R				×		×	×	×	×	×	
Python				×		×	×	×	×	×	
Kahoot	×	×				×	×		×		×
Padlet	×	×			×			×	×		×
i-Pencil/Notability	×	×	×	×	×			×	×		×
Classmarker						×	×	×			×
Mathlab calculator	×	×		×	×	×		×			×
Web assign						×					
Tinkercad				×		×	×	×		×	
PHET	×	×		×			×	×		×	
Physics studio	×			×			×	×		×	×
Verbe	×	×		×			×	×		×	
Physics toolbox suite	×			×			×	×		×	

4.3. Impact Learning Measured through Final Grades as Compared with the Student Opinion Recommendation

The second research objective deals with the impact of resources and methodologies under the Hyperflex model. Despite this, as was previously stated, such impacts should be measured not only through the summarized final grade but also in terms of engaging learning to students, so a contrasting perspective is considered. Due to the diversity and foci of the set of courses analysed, we should reach such analysis with the more comparable indicators available. Thus, one of those was the opinion of students, which strongly measures engagement.

In our institution, at each end of the semester, a uniform exit survey is applied to each student to evaluate the services and particularly the performance of each course design and teacher. For each course, a set of questions is applied as a function of their characteristics (theoretical, experimental, entrepreneurship, etc.). However, in any case, a global final question is considered, the recommendation of the teacher, considering there the dominion, accompaniment, support, design, and methodology applied in the course delivered.

That question is common for all courses and teachers, and it is expected to be answered as a recapitulation of the different components assumed for each one. Despite this, the survey is criticized because it is supposed to be related to the ease and flexibility of the course. However, in the implementations being analysed, flexibility was one of the aspects that could be exhibited as something positive. In addition, it was expected that survey reflected the utility and value of the course delivered. In addition, previous analysis of institutional exit surveys has shown that the outcomes mainly appoint to the must be of education, thus, ease is punished as well as unnecessary complexity [56,57].

With this purpose, we propose to contrast the outcome in the final common question in the survey mainly with the average of final grades, but still together with its standard deviation and other parameters. Other factors could be important in distinguishing the set of data, as for instance academic area, period, as well as the main innovation considered in the course revealing hidden behaviours during the lockdown.

The last aspect has been classified in three tracks as the teacher considered the main aspect innovated in the course: (a) Introduction of supporting technology, (b) Introduction of disruptive methodology, and (c) Design based on the constructive and flexible evaluation. Corresponding data for the 66 groups being considered in the study are synthetically represented in Figure 5 in agreement with the data shown in the Tables A2–A4.

The plot exhibits each group considered in a dispersion plot between the average of final grade on the horizontal axis (the common scale is 0–100, but here it has been modified to easily to compare data on a 0–10 scale) and the average of student's recommendation for the course (in a scale 0–10, where 10 is the best recommendation). Each dot representing a group surrounded by a circle whose radius reflects the corresponding standard deviation of final grades in each course.

Each dot is represented in a colour corresponding with their academic area: black (MS), yellow (NM), and orange (PE). In addition, circles were coloured in agreement with their type of innovation: red (Technology), green (Methodology), and blue (Evaluation): together, the edge of circles are dotted, dashed, or solid respectively in agreement with the period each one corresponds. All corresponding scale legends are included on the left as a visual reference. The diagonal line in brown remarks the identity between both main indicators on the axes.

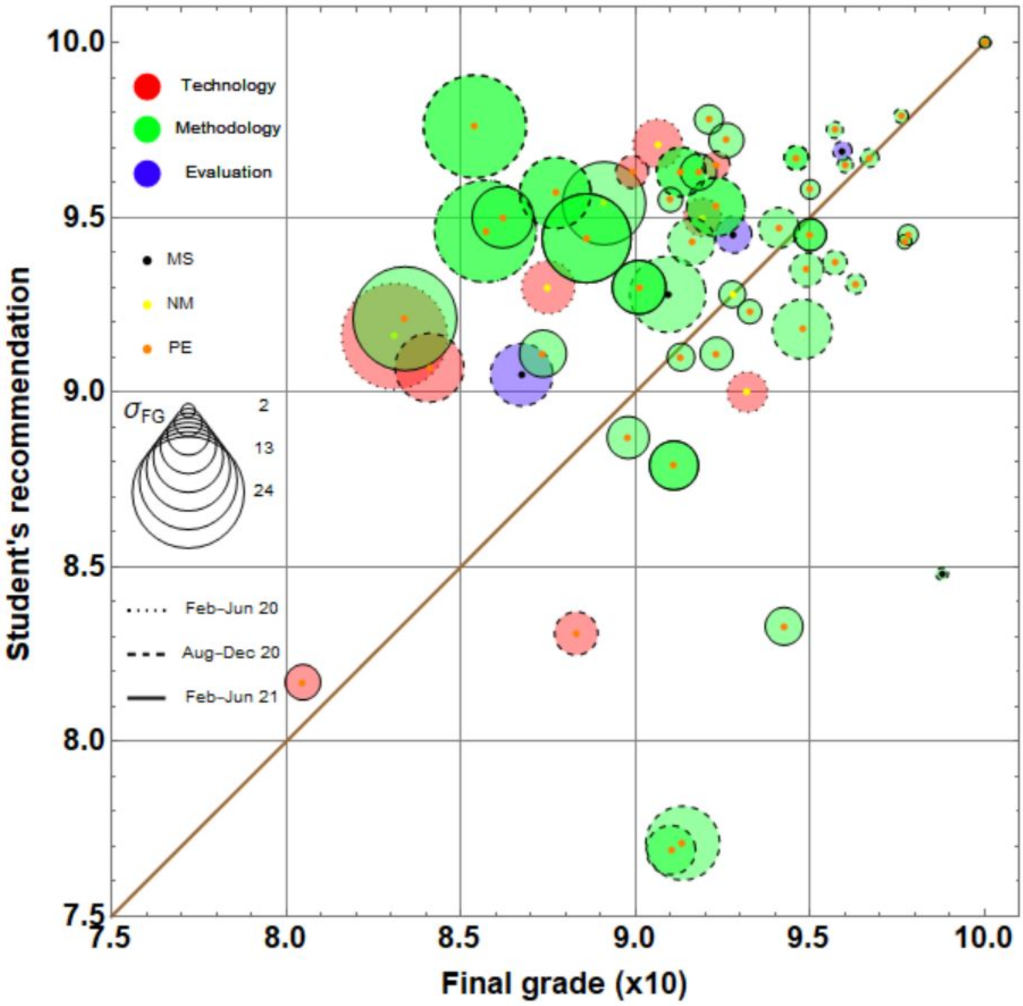

Figure 5. Final grade versus Student's recommendation evaluation to each teacher (scale 0–10) for the classes under analysis. Variables as Innovation type, Course group, Standard deviation of Final grade, and Course period are also represented in agreement with the scales on the left.

The dispersion plot in Figure 5 indicates some possible trends of analysis on the data [58]. At first glance, several aspects become evident. First, the distribution shows an apparent higher average recommendation than the average final grade value for at least one point more. In general, recommendations became higher during the lockdown period than before for around one half-point at least than the historic registers (the average recommendation for the courses in the Science department was 8.89 during 2019, while the recommendation average for the groups reported between 2020–2021 became 9.32).

Most of the courses are outstanding due to their Methodology (85%, green) rather than other innovations, with Technology (15%, red) as the second innovation in recurrence. In addition, courses proposing Methodology as innovation appear better recommended than those centering on Technology or Evaluation (despite the few data for these last). Differences among periods are not evident or they are few clear due to the meaningfulness (as for those of MS).

A particular behaviour for those courses was the extended dispersion in the final grades, which appeared apparently with the largest values of recommendation (despite, other courses with a larger dispersion still did not exhibit such behaviour). We will analyse those aspects more deeply below. Those aspects related to the meaningful dependence of the student's recommendation are analysed in Figure 6.

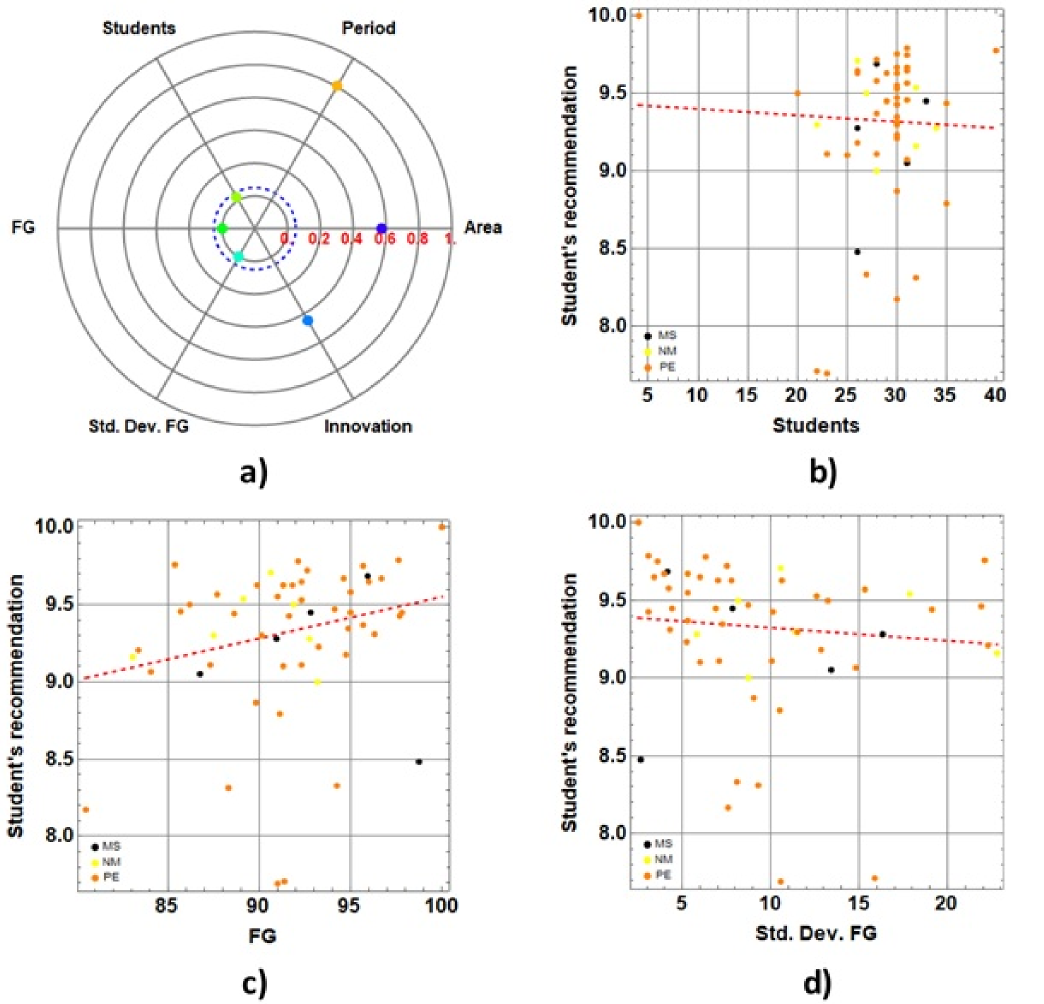

Figure 6. (**a**) Radar plot of $p-$values for one factor ANOVA tests between Student's recommendation values (SR) and Period, Number of students (S), Final grade (FG), Standard deviation of FG (SD), Type of innovation, and Academic area. (**b**–**d**) The dispersion plots for the meaningful explanation variables found in (**a**) including the single linear correlation models. Despite that the analysis does not distinguish the Academic area, dots are coloured in agreement with colours in Figure 5.

We are now interested in the meaningful explanation of the student's recommendation concerning the variables: Period (the semester when the class was delivered), Number of students (S), Final grade average (FG), and Standard deviation of FG (SD), Type of innovation (Technology, Methodology, or Evaluation), and Academic area. Then, one-factor ANOVA tests were performed in each case, obtaining their corresponding p-values, which were synthetically plotted on Figure 6a presented in a radar plot (note that zero value for p is not in the origin for better reading), remarking with the blue dashed circle the significance of the tests, which was 0.05.

If $p < 0.05$ denotes a sensible correlation [59], we noticed that only the S, the FG, and the SD were meaningful for the variation explanation of the student's recommendation. For some outliers will be interesting to know specific situations that occurred there. Such cases will be discussed concretely in the next section. Figure 6a–c shows the corresponding dispersion plots between those meaningful variables with the student's recommendation values. Plots include red lines for the linear correlation dependence under a single linear explanation model to reveal the kind of the dependence (positive or negative).

This analysis is useful to understand the main trend behind the functional behaviour on each independent aspect. Despite that the Academic area is not meaningful and its values are not discriminated in the analysis, we coloured the dots as a reference in agreement with their colours in Figure 5.

Some immediate outcomes show that Student recommendation depended positively on the final grade of each course and negatively on the standard deviation, despite an expected outcome, note that not the highest grades were expected by the students to assign the best evaluation to the teacher. However, dispersion could be expected to be narrower, probably because the effort among partners could seem relatively similar to others in the current circumstances.

Another interesting, but not so strange outcome, is that larger groups tended to decrease the recommendation value to teachers. Obtaining the correlation with a linear model between the student's recommendation (SR) and the meaningful variables obtained, we obtain the Pearson correlation coefficient [59] $r = 0.28$ (while taking all variables involved it barely raise to $r = 0.30$ confirming the low meaningfulness of the remaining variables). Nevertheless, a more optimal second-order model gives:

$$\begin{aligned} SR \;=\; & -13.322 - 1.386 \cdot S + 0.130 \cdot SD + 0.907 \cdot FG + 0.003 \cdot S^2 + \\ & 0.013 \cdot S \cdot FG + 0.011 \cdot S \cdot SD - 0.007 \cdot FG^2 - 0.006 \cdot FG \cdot SD + 0.002 \cdot SD^2 \end{aligned} \tag{1}$$

with the three meaningful variables (number of students S, final grades average FG, and standard deviation in the final grades SD) giving $r = 0.57$, a notably improved value at double (a similar second-order model with all variables simply raises it to $r = 0.66$).

In this analysis, we have considered only academic or demography factors as causal factors on the student's recommendation evaluations for the courses as an indicator of effectiveness. Despite this, several external elements in the emotional scope were identified as important factors in the academic success of the student. Those factors are diverse, but they affected the students in different strengths, thus stating lots of long-term consequences [60]. We discuss some findings in our student community related to those aspects in the following subsection.

4.4. New Opportunities and Main Losses around Academic Life during the COVID-19 Lockdown

As part of our research, our third objective was boosted because the emotional component was diverse among the student community, thus changing, improving, conditioning, or altering his academic life. Despite that certain analyses during the period have appointed digital competencies as the key factor of successful learning, which is true as well for teachers as for students [61], secondary factors arose in communities with a sufficient dominion of educational techniques and technologies, and also students could still benefit from other opportunities opened by the different conditions.

Then, at the end of the three semester period, a part of our students between the first and fourth semester within the courses of the teachers' cluster was randomly asked about the new opportunities about the changes boosted by the COVID-19 lockdown had produced on them. On the other hand, they also were asked about those incidents mainly affecting negatively their academic life. Note that the two answers were mandatory for each student to evaluate both positive and negative facts. The outcomes were then classified, and thus proportionally reported synthetically on Figure 7a,b, respectively.

For the positive aspects, students recognized mainly the inclusion of more meaningful challenges or projects involved in their courses, an augmented deepness in their learning due to the time-released by the confinement, and the increased sense of effort and discipline to fulfil their academic duties. Those aspects represented the 70% of responses. The negative aspects were more diversified including mainly the failed courses, the low grades, difficulties in adaptation to teaching styles, and the complexity present in the course challenges or projects.

Those aspects represented almost 60% of the responses, while the remaining appeared equally distributed between academic, technology, and family issues. Note how some of these appear as opposite facts—clearly as responses of different parts of the group of students surveyed.

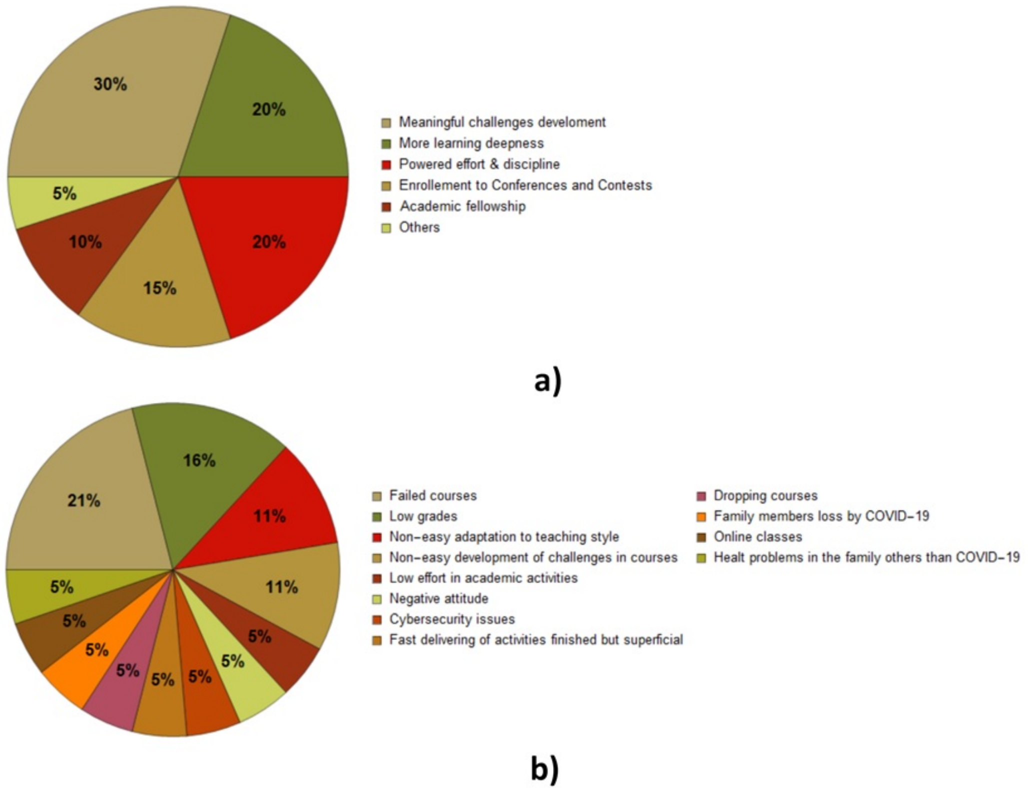

Figure 7. (**a**) The best opportunities open during lockdown, and (**b**) Situations affecting academic life during lockdown. The survey was applied randomly to 10% of students involved in the current study at the end of third semester of lockdown. Percentages were floor rounded to the closest integer.

In the following section, we will discuss the last findings by objective. We will relate and extend some facts presented here, thus, giving a closer and concise interpretation of the outcomes and quantitative analysis developed in the straight analysis.

5. Discussion

5.1. Evolution and Stability of Didactic Designs

The most traditional models of education required mainly a syllabus to be delivered, together with few tasks to be developed in class or extra-class. As LT evolved, the introduction of specific stimulus in the form of learning activities began to introduce more detailed caring of didactic designs [35]. As we are shown in the reflexive task of design in the Figures 1 and 3, didactic elements introduced certain specialized activities in terms of differentiated learning in terms of skills, deep learning, engagement, professional practice, or still diversified learning styles [28]. Such increased effort by itself is an input gain in education due to the COVID-19 confinement [36].

Implementation of technologies and alternative methodologies during the COVID19 lockdown began to be implemented progressively as normally occurred in other experiences [62] and expected in terms of CCLT approaches [8]. The original concern was to offer an alternative channel to replace the face-to-face class, thus introducing video classes through a proper tool.

Teachers additionally sought tools to stay in contact with and among students in a nearer way than the already implemented courses on LMS [63]. However, it soon became clear that those emergent elements were insufficient when only combined with the same elements previously present in the face-to-face version. Thus, alternative and diversified methodologies were emerging to cover specific necessities in each course.

During the beginning of lockdown, despite the institutional efforts and previous knowledge provided by pre-pandemic teacher training in educational technologies [30], each teacher has the perception of starting an uncertain adventure in education with difficulties to have a big picture of the situation more than replicate their face-to-face practice still in a proven BL approach [27].

Many academics still took the challenge without realizing the necessary effort to provide an effective learning experience for their students [26] in terms of design, technological dominion, continuous assessment, and diversified input channels. As part of our first research objective, we learned from the low plot in Figure 4, that such increasing diversification and dominion was settled through time and experience, being additionally transferred to similar areas by recommendation due to the collaboration cluster. Particularly, it is noticeable that certain stabilization was reached after only three semesters of practice despite the changes in the courses taught.

5.2. Didactic Designs Dimensions Improved: Superseding the Traditional Teacher' Knowledge and Perceptions

Since blackboard substitutes, which gradually were adapted to better solutions, until methodologies emphasizing certain aspects of learning -individual or social-, together with diverse learning stimulus, teachers were gaining a wider dominion about their new instructional practice. Students should also adopt such specialized technologies progressively as soon as it has been advised in the knowledge areas [64]. Such aspects were registered through the practice as Table 2 summarizes for our first research objective together with the behaviour noticed in their implementation (Figure 4).

Thus, after such an unclear beginning, other elements were configuring improved versions for the courses depending on the area, emphasis, contents, and semesters where they were allocated. In addition, evaluation was a permanent concern, as well to avoid frauds as to be a purposeful instrument extending the learning during such activity, despite the compromised learning due to the continuous and permanent online sessions, particularly in areas requiring experimentation and practice [65].

5.3. Students' Recognition on the Course Effectiveness and Its Close Relation with the Learning Performance

Some lessons were learned as a result of our second research objective remarked by the analysis of the progressive implementation in a segment science courses. Recommendation inside of a teachers' cluster by sharing and testing technology and methodologies in their courses made clear that implementations were not ready since the beginning, instead, they were a continuous and adaptive improving to an ideal instruction assessed by the students' responses. In any case, outcomes exhibited a good response of students expressed in the exit opinion survey of each one. Some remarks and exceptions should be commented on in terms of the rare outliers shown in Figure 5.

By analysing the data in Tables A2–A4, we found that a meaningful correlation between the student's recommendation and the final grade was present but to the right extent. This is natural because students expect the grade to reflect their effort in each course. We note that correlation is not functioning as an identity, which means that students give the maximum recommendation without expecting the highest final grade. Other behaviour is noticed with the dispersion of grades; nevertheless, running a one-factor ANOVA test between the number of students and the standard deviation of final grade, we found $p = 0.22 > 0.5$.

This indicates that there are almost null correlations between those variables, and thus larger groups do not necessarily imply more dispersion in the final grades. If this fact is solely attained to the students (otherwise there is not also a correlation between such dispersion and the type of course in any sense), then this possibly uncontrollable factor affects the final perception of the students on the course, not the group size necessarily.

Certain outliers appearing in Figure 5 should be commented. For the outliers with SR equal to 7.69 and 7.71 for F1006B and F1007B respectively (Kinematics and Mechanics for Mechanical, Industrial and Mechatronics engineering programs) in Table A1, this course had an asymmetry between professor and student evaluations. This is likely due to the fact such a course was the first of this kind in a digital model for most of the students (both courses were consecutive during the semester, five weeks each one and with the same students).

In addition, the group composition in dominion was uneven, and thus the styles and rhythms made an important gap in the learning process. In addition, bad students' attitudes were also observed there: from lack of interest to participate until inclusively inappropriate behaviour behind the camera. On the other hand, the same methodology and technology were employed in another group with better results for the professor's evaluation.

In the other extreme, classes F3026 and F3029 (Physics engineering project I and II) obtained 10 in SR. With only four students, they have the freedom to select their projects in agreement with their interests. It was a small experimental class that stated a closer contact among students and teacher boosting compromise. Thus, commonly good didactic management gives a higher SR as was the case here.

In an aftermath exercise of reflection about the findings for the second research objective, despite the extended effort devoted to design and with an uncertain outcome in the engaging and learning of students, the teachers' group consensus met the following key points: (a) students had a responsible act of learning, (b) they responded to the effort of teacher, (c) they were respectful about the teacher's time by using effectively the flexible learning spaces when those were effectively open, and (d) despite the possible limited adaptations to the teaching styles and designs, students appreciated them as a genuine effort to deliver valuable teaching.

Despite this, it was also believed by our cluster that all those recognized behaviours were only reached after a thoughtful design and self-assessment teaching work by each teacher and then for the cluster effort. Particularly, we agree that CCLT provided an effective mirroring of the students' expectations to learn.

5.4. Biased Perceptions about the Academic Life during the Outbreak

As many other factors were observed conditioning the perception of the course, which ranges from little adaptability to the didactic strategy selected by the teacher until domestic facts affecting the courses (electricity and internet services, family issues, study environment, etc.) [66], our third research objective was to account for the happenings of our students.

One of the most affecting issues in Science and Engineering is the absence of laboratories. This practice was supplied by homemade practices and technologies when they were possible and available, otherwise by simulation labs, or with challenges in the form of simulation projects replacing it, an old innovation that works [22]. For the first four semesters of science and engineering programs, it was not a student complaint except for the last semesters with more specialized labs (which are not the main part of this analysis).

We state that many other such found happenings were not cared about because they were not deliberate or otherwise; we did not provide adequate spaces to support the students in such issues. One of the opportunities from staying in the university facilities is the closer contact with teachers and partners, the accessibility to academic opportunities as conferences, contests, the related program works, and so on. Notably, for part of students, the access to those activities disappeared when they disconnected from the face-to-face contact.

Despite this, the recounting was done about students' opportunities and losses, still limited, which shows that differential events but also attitudes have settled opposite life paths during the lockdown, particularly for academic life. While several activities were maintained in the courses in the form of challenges (projects, experimental or simulation constructions, etc.), they were meaningful learning opportunities for the great part of students (30%), but for another minor part ($11\% + 5\% \approx 16\%$ possibly) were not. Similarly, $11\% + 5\% \approx 16\%$ expressed difficulties for the adaptation and necessary effort in the Hyperflex model.

Notably, around 20% of the population surveyed expressed the search and participation in external and specialized academic conferences and contests, but until $21\% + 16\% + 5\% \approx 42\%$ expressed in contrast difficulties with low grades, or still failed or dropped courses. Behavioural well-being affected different people and particularly students in their academic life around the world [63], becoming concomitant with limited courses designs and accompaniment in the academic life.

Thus, in terms of the third research objective, the COVID-19 lockdown has shown us absent complementary elements of design and following for our students under BL (from each course but not only since them). It has also shown that many other factors of success are present in distance learning than in face-to-face learning, despite this time COVID-19 scenario added special and critical elements than an ideal scenario for BL. Here, the more noticeable aspect is that some new opportunities or losses were generated externally to the educational spaces.

Teachers were normally worried about punctual aspects by covering their courses, but the common academic life extends much further than that, with the common interaction, opening, and academic offerings coming from the same teachers. Despite this, it was limited and often unplanned, being accessible only to those students exhibiting a more self-generated academic strength. Future designs coming from teachers should extend those wider opportunities and support, thus recovering the university spirit.

6. Conclusions

We presented and analysed the progressive implementation of technological and methodological resources to improve the effective delivery of a sample of science courses in three different campuses of a Mexican university system. This sample was characterized because it was taught by a cluster of teachers sharing the new implementation of methods and technologies with specific goals in the teaching of math, statistics, numerical methods, simulation, and physics courses, mainly ranging from the first to fourth semesters of several programs of science and engineering. All innovations were open to new perspectives in education, mainly in terms of CCLT.

The research objectives covered the analysis of gradual appropriation of those resources, thus, finding new opportunities in didactic design, past than the COVID-19 pandemic itself. Teacher collaboration exhibited a fast implementation and stability through the three semesters of the strict COVID-19 lockdown. Students' engagement and effort recognition were contrasted with several other academic parameters showing interesting outcomes in terms of discipline, respect, and resilience. Despite some gaps to the ideal outcomes, students showed an effort to follow the instructional design established, thus, exhibiting a generally good response to the cluster response.

The innovations considered improved the exiting student's recommendation given to each course, improving its historical value by around 5%, despite the complex, new, and partially improvised scenarios compromising the optimal delivery. The recommendation partially depended positively on the final grade average assigned to the group together with a negative dependence on the standard deviation of the final grade in the group, thus, exhibiting a faithful recognition of the didactic design under the Online Learning model proposed and the diverse variation of the learning stimulus introduced.

Teachers within the collaboration cluster evaluated such perception and interpretation positively. Still, despite the apparent similar conditions, outliers showed that, if some negative factors are combined, the student perception could become drastically affected.

A closing term survey applied at the end of the three semesters of the lockdown (before the New Normal opening of educative activities, in the confinement period) suggests that students focused on the positive and negative incidents during the pandemic as a function of their personal experiences and their attitude concerning the restrictive and confinement period. Those facts and position affect the course's recommendation because some of them advise opportunities and others advise losses derived from their academic conditions.

Such aspects appeared as not cared about or deliberately promoted issues, thus, stating opportunities for the teaching practice, particularly under an emergency education.

For teaching practice, as well for theories of education, the COVID-19 confinement has been rich in lessons as a sudden ongoing learning on the more realistic and largest teaching lab. The lockdown period has let us realize some blind aspects around the representation of the university since the teacher individuality through his teaching delivering, thus, effectively replacing the physical university facilities.

Under this view, teachers, as well as the students, should have a pro-positive attitude, the best spirit to improve not only Online Learning education but also the entire teaching practice as a thoughtful exercise of renewal in didactic design, reflection about an effective and conscious LT implementation as an affordable via for future models of education in general, possibly under a more benign, enduring, and planned settlement in the next term of human history.

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Data Availability Statement: Data sets were obtained from sensitive individual grades of students from institutional and author records, then processed losing their individual character for the statistical report. They are partially available upon request to the authors.

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Abbreviations

The following abbreviations are used in this manuscript:

BL	Blended Learning
BLT	Behavioural Learning Theory
CEM	Campus Estado de México
CGLT	Cognitive Learning Theory
CNLT	Constructivist Learning Theory
CCLT	Connective Learning Theory
CSF	Campus Santa Fe
FG	Final grade
HLT	Humanistic Learning Theory
LT	Learning Theories
LMS	Learning Management System
MS	Mathematics and Statistics
MTY	Campus Monterrey
NM	Numerical Methods and Simulation
PE	Physics and Engineering Sciences

Appendix A. Data Collections Used in the Analysis

This section gathers the group information considered in the analysis of Section 4. First, Table A1 collects some codification of data presented in the further tables by Period (semester of 2020 or 2021 when course was taught), Innovation type (Inn), and the campus. Further information is reported in Tables A2–A4.

Table A1. Data for courses of MS considered in the analysis.

Period		Innovation	Type	Campus	
1	February–June 2020	1	Technology	1	MTY
2	August–December 2020	2	Methodology	2	CEM
3	February–June 2021	3	Evaluation	3	CSF

Table A2. Data for courses of MS considered in the analysis.

Period	Course	Students	FG	SD-FG	SR	Inn	Sem	Campus
2	MA1026	26	90.92	16.36	9.28	2	3	3
2	MA1027	26	98.77	2.67	8.48	2	1	3
2	MA1035	33	92.80	7.86	9.45	3	3	3
2	MA1035	31	86.74	13.43	9.05	3	3	3
2	MA1035	28	95.92	4.14	9.69	3	3	3

Table A3. Data for courses of NM considered in the analysis.

Period	Course	Students	FG	SD-FG	SR	Inn	Sem	Campus
1	M2009	22	87.50	11.40	9.30	1	4	2
1	M2009	28	93.20	8.70	9.00	1	4	2
1	M2009	32	83.10	22.78	9.16	1	4	3
1	M2009	26	90.63	10.59	9.71	1	4	3
1	M2009	27	91.91	8.18	9.50	1	4	3
1	F1014B	30	92.30	12.60	9.53	2	2	3
1	F1006B	31	85.70	21.90	9.46	2	1	3
2	F1004B	31	94.60	5.30	9.67	2	1	3
2	F1004B	30	91.30	10.60	9.63	2	1	3
2	F1005B	31	87.70	15.30	9.57	2	1	3
2	F1005B	30	85.40	22.10	9.76	2	1	3
3	F1013B	32	89.10	17.83	9.54	2	2	1
3	F1014B	34	92.77	5.80	9.28	2	2	1
3	F1013B	35	91.10	10.50	8.79	2	2	3
3	F1013B	30	90.10	11.50	9.30	2	2	3
3	F1014B	35	88.60	19.10	9.44	2	2	3
3	F1014B	29	95.00	6.90	9.45	2	2	3

Table A4. Data for courses of PE considered in the analysis.

Period	Course	Students	FG	SD-FG	SR	Inn	Sem	Campus
2	F1004B	31	84.10	14.80	9.07	1	1	2
2	F1004B	26	89.90	7.00	9.63	1	1	2
2	F1005B	32	88.30	9.30	8.31	1	1	2
2	F1005B	26	92.30	6.00	9.65	1	1	2
2	F3026	4	100.00	2.50	10.00	2	7	1
2	F1004B	31	94.60	5.30	9.67	2	1	1
2	F1004B	30	91.30	10.60	9.63	2	1	1

Table A4. *Cont.*

Period	Course	Students	FG	SD-FG	SR	Inn	Sem	Campus
2	F1005B	31	87.70	15.30	9.57	2	1	1
2	F1005B	30	85.40	22.10	9.76	2	1	1
2	F1001B	31	96.00	3.40	9.65	2	1	1
2	F1001B	31	97.60	3.10	9.79	2	1	1
2	F1001B	31	95.70	3.60	9.75	2	1	1
2	F1014B	30	92.30	12.60	9.53	2	2	1
2	F1008	30	94.10	8.70	9.47	2	2	1
2	F1008	28	95.70	5.30	9.37	2	2	1
2	F1006B	31	85.70	21.90	9.46	2	1	1
2	F1013B	30	91.60	10.10	9.43	2	2	1
2	F1018B	30	96.70	4.00	9.67	2	2	1
2	F1008	30	94.90	7.30	9.35	2	2	1
2	F1008	30	96.30	4.30	9.31	2	2	1
2	F1006B	23	91.01	10.57	7.69	2	1	3
2	F1006B	26	94.77	12.86	9.18	2	1	3
2	F1007B	22	91.35	15.88	7.71	2	1	3
3	F1016B	30	80.48	7.61	8.17	1	2	3
3	F1013B	35	91.10	10.50	8.79	2	2	1
3	F1013B	30	90.10	11.50	9.30	2	2	1
3	F1014B	35	88.60	19.10	9.44	2	2	1
3	F1014B	29	95.00	6.90	9.45	2	2	1
3	F2002B	30	83.40	22.30	9.21	2	4	1
3	F2004	40	92.10	6.30	9.78	2	4	1
3	F1008	29	97.80	4.40	9.45	2	2	1
3	F1008	30	97.70	3.10	9.43	2	2	1
3	F1009	20	86.20	13.20	9.50	2	3	1
3	F3029	4	100.00	2.50	10.00	2	8	1
3	F1013B	29	91.80	7.80	9.63	2	2	2
3	F1013B	30	91.00	5.30	9.55	2	2	2
3	F1014B	28	92.60	7.50	9.72	2	2	2
3	F1014B	28	95.00	4.20	9.58	2	2	2
3	F1015B	30	93.27	5.23	9.23	2	1	3
3	F1008	30	89.79	9.05	8.87	2	2	3
3	F1008	27	94.25	8.10	8.33	2	2	3
3	F1008	28	92.32	7.06	9.11	2	2	3
3	F1008	25	91.30	6.00	9.10	2	2	3
3	F1017B	23	87.35	10.0	9.11	2	2	3

Thus, in the last tables, data are presented by including in addition the course code as it could be consulted in our institutional repository [67] for the undergraduate science and engineering programs. Note that some courses whose code begins with F still could be allocated in NM courses due that courses whose codes ending with B are integrated courses, and they have three teachers and components: Physics, Math, and Computing [48]. *SD* refers to the standard deviation of each group final grades, while Sem refers to the semester that should be coursed (1 to 8) within the undergraduate program.

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