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Course design process in a technology-enhanced learning environment

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ABSTRACT

This manuscript reports on the design strategy of a "*Citizenship and Technology*" course for undergraduate students under the new Tec21 Educational Model. The design was proposed in a mixed-model scheme. One model incorporated face-to-face sessions in Remote Interaction Rooms through the Zoom Rooms application, and the second model involved the use of didactic strategies using Information and Communication Technologies. After the first implementation, we detected areas of opportunity that signaled the need of making important adjustments in the activities design. These adjustments are needed for four main goals: generate evidence of competence development; make adjustments to class dynamics for the correct teaching process, simplification of the evaluation mechanisms and reconceptualization of special guests profile. The data collection was carried out through partial surveys and course grades. We analyzed the impact of these adjustments on the assessment of the evaluation by the students to the class and the teaching team.

1. Introduction

In August 2019, the Tecnologico de Monterrey (Tec Mty) began to implement the *Tec21* Educational Model [1, 2]. It is based on four fundamental pillars: A) Challenging and interactive learning experiences, B) Flexibility in the teaching-learning process, C) The building of a memorable university experience and, D) Inspiring and innovative teachers [3].

In this context, a general education subject called *Citizenship and Technology* was designed. The main characteristics of the course were:

(a) Interaction with experts: the course is led by a Professor (a recognized academic expert in the field), and divided into sections led by highly recognized guests in their academic or industrial field;
(b) Interaction with other campuses of the Tec Mty system: construction of a learning community at the national level;

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Table 1
Teaching team and their responsibilities.

Professor	Tutor	Facilitator
Design and deliver the course	Support the professor in the design and delivery of the course	Maintain group control in the RIC
Train the tutors and facilitators	Give personalized follow-up to the student	Supports the Professor in coordinating the participations and carrying out the activities in the RIC
Give personalized advice to students on demand	Grade the activities	Resolve possible technological problems in the RIC
	Give feedback	

(c) Interaction through state-of-the-art technology: Learning spaces adapted for synchronous multi-campus connection (Remote Interaction Rooms and Zoom Rooms; [4]).

This teaching model was called ***Elite Class*** (because all participants are highly recognized in the academic sphere, that is, they are "an elite"). This kind of courses has two components:

(1) A synchronous learning environment in real time with moments of face-to-face interaction between teacher and student. The live sessions, lasting two hours and twice a week, are mediated by technology and are taught by renowned professors and invited national or international experts. This allows for an interactive learning experience in which, thanks to technology, geography is no longer a barrier to learning and interacting with colleagues from different campuses;

(2) An asynchronous environment based on technology with content, resources or didactic activities previously designed and available to the student on the CANVAS platform [4].

Elite class [5] use Remote Interaction Classrooms (RIC) [6], which are educational spaces distributed throughout the different Tec Mty campuses adapted with the following technological resources: interactive projector, tablet to control the Zoom rooms, monitor to view the active speaker/multiview with campus, microphone, speaker and teacher microphone. In addition to this, the transmitting rooms have an additional projector that shows the multiview of the campus.

Zoom Rooms is a video conferencing system whose software is capable of running in multiple conference rooms. Participants meet from mobile phones, tablets, desktop computers, and room systems. It has touchscreen meeting controls on an iPad that moderates the session and enables interaction between participants. In addition to this, it has a multi-screen viewer that shows the active exhibitor, in this case the teacher, the content and the view of all the participants (campus), as well as wireless screen sharing, with transmission replication, with the that can share various multimedia contents [7].

The teaching team is made up of *a full professor*, one or more *tutor professors* (depending on the number of students enrolled) and a *facilitator* located in each of the campuses. Table 1 shows the responsibilities of each of the members of the teaching team. The tutor is an expert teacher in the topics that accompanies the student in a personalized way in their learning process, using the didactic-pedagogical elements and using electronic communication tools to guide them in their activities and provide feedback on their learning activities.

The design process of this subject was multidisciplinary. The teaching team was made up of professors from the areas of social sciences, humanities, and educational innovation at Tec Mty. The Professor is present in one of the groups in the classroom (transmitting campus) and leads the class and interacts with students from other campuses (receiving campuses), who are accompanied by facilitators [7]. The teacher has a smart board and mobile cameras that are activated by a sensor that the teacher puts on as a collar. On the other hand, the RICs have a double screen: one linked to the smart board so that students can see the material shared by the teacher and the other with the teacher's view.

In the fall of 2019, during the first implementation of the course, the following areas of opportunity were detected:

(a) technology allowed synchronous sessions with the students at different campuses (reception rooms), however, the engagement of them was not properly achieved, generating an attitude of general apathy towards the Elite class.
(b) the participation of the guests, of whom the model expected a greater impact, was not observed in all cases, particularly when the generation gap between the guest and the students was wide.
(c) the learning activities designed for a dynamic experience during the class generated a substantial academic load for the students and for the tutor teachers. The students could not relate the activities to the problem situation (academic challenge of the course) that assesses the competencies.
(d) across campuses, the students showed difficulty in maintaining attention throughout the class.

After an analysis of the first implementation, the course was redesigned, implementing improvement actions in the following semester and then we compared the indicators of both courses. Our results showed that the modifications made had a positive impact on the academic performance of the students and on the evaluation of the teachers.

In the first place, the article presents the theoretical framework, that is proposed by Design-Based Research (DBR) to document the obstacles of the project. We use case study as methodological approach to keep record of the academic experience. Next, we detail the academic experimental settings: course description, design and redesign process, technological tools, satisfaction surveys opinions and general student performance results. Finally, we conclude presenting the most important findings we developed to implement in an undergraduate hybrid course.

2. Theoretical approach

The analysis of the design, performance and indicator analysis of this Elite class was carried out considering the context of a new Educational Model (*Tec21 Model*) [1,2] and a highly *technological learning environment* (TELE). To this end, we decided to conduct a *Design-Based Research* (DBR) intervention to document the obstacles we faced in the design process and during the first implementation of the course in order to enhance the new learning experience and offer new theoretical perspectives on remote interactive classes. Mingfong, et al. [8] suggest four design features to create effective interventions: "frameworks for learning, the possibilities of the chosen instructional tools, the presentation of domain knowledge, and contextual constraints". Wang and Hannafin define DBR as a "systematic but flexible methodology aimed at improving educational practices through iterative analysis, design, development and implementation, based on collaboration between researchers and professionals in real world settings, and leading to early context sensitive design and theories" [9]. In addition, several researchers [8,10–13] consider that its basic characteristics are: progressive, interactive, iterative and flexible refinement in design; practical and theoretical purpose; contextually dependent interventions; collaboration between professionals and researchers [10].

3. Methodological approach

Design-based methodologies are especially important considering technology-enhanced learning environments like our Elite class. In other words, design is conceived not only to meet local needs, but to advance a theoretical agenda, to discover, explore and confirm theoretical relationships [14]. Design methodologies are generic procedures that guide the process, for example, how to achieve a design goal and develop the necessary expertise. They can be comparative profiles similar to a consumer report [15], principles in the form of heuristics, case studies or longitudinal studies [10]. Findings are more than prescribed activities for other designers to follow; they transcend the context of the immediate problem to guide designers both in the evolution of the relevant theory and in the generation of new findings.

In this case, we use a case study framework [16] to document an undergraduate general education class: *Citizenship and Technology*. The undergraduate class is a hybrid course, combining classroom activities and online activities. These types of classes are growing rapidly in the current context of the COVID-19 crisis [17]. Global confinement represents a great opportunity for those who promote that university teachers stop being mere disseminators of content and become designers of learning experiences [18]. According to Pardo-Kuklinski and Cobo [18]: "the first reaction of some teachers is to transform all the content and the face-to-face experience to a virtual environment without further adaptation, as if it were copying and pasting", but it is evident that the change environment is also a rule change. We must not forget that the most critical challenge of hybrid courses is to generate and maintain the interest and participation of students within the class. One of the aspects that in general is more questioned is that effective interactions between teacher and student are not provided and student-student cooperation is hindered [19, 20]. Therefore, to be successful, a hybrid course must create a learning environment that fosters the development of a shared learning community among those who make up the class, namely teachers and students [17]. This requires a more asynchronous interaction that allows dialog and mentoring to produce results similar to face-to-face courses [21].

Part of the solution is to permanently remove the barrier between face-to-face and virtual training, and to design the academic experience as a single expanded multimedia narrative timeline where the teacher and students can collaboratively use the best of both worlds, with an inventory of their own and external content arising from intense curation and adjusted to a learning sequence. A successful distance learning content strategy lies in thinking of content as the finite timeline of an extended transmedia narrative. This narrative encompasses synchronous and asynchronous moments, as well as passive consumption content (from one to many) and others with the student in the role of prosumer (users who are **pro**ducers and con**sumers** at the same time). Babb et al. [17] reported good hybrid instruction practices. These include: multiple user-friendly websites (platform, messaging, mail), well-designed assignments, active online communications, development of learning communities, fast and high-quality feedback mechanisms, and communication of high expectations regarding the course. Each of these practices can be used to create a presence when face-to-face interaction is not always a viable option.

4. Academic experimental settings

4.1. Course description and design process

The *Citizenship and Technology* class is a general education subject belonging to the general area of *Ethics and Citizenship*. General education classes are offered to all students, regardless of their academic area, during the first three semesters of the university studies. In the Tec 21 Model, competencies are defined as: "the conscious integration of knowledge of certain situations. The competences integrate both the knowledge and the procedures of the discipline, as well as the attitudes and values that allow the training of participatory professionals committed to society" [3].

The design of the *Citizenship and Technology* course was carried out in an approximate period of 9 months and included members of the Faculty of Social Sciences and Government and the Faculty of Humanities, with the support of instructional designers of the Vice-rectory for Educational Innovation of Tec Mty. The process began with three intensive sessions of 8 h where the teaching team, together with the instructional designer, defined the didactic technique, the didactic learning sequence, the evaluation plan, the content of the syllabus and the bibliography of the subject (having considering the transversality of competences). To achieve this, tools were used to represent the course sequence (review material, interaction, feedback, support activities and evidence) at different

times (before, during and after each synchronous session). The design of the specific contents was complemented remotely by the course teachers and reviewed and discussed collectively in weekly sessions through Zoom.

Finally, the design includes, as an essential part, the invitation of prominent personalities from their professional area who arouse interest in the public agenda. This element makes the course a very attractive option compared to other courses that develop the same or similar skills. The first implementation of the course took place in the fall semester of 2019. After it, a redesign of the course based on DBR was carried out, where elements were adjusted to improve the hybrid experience, mainly in terms of optimizing student engagement with the challenges and course content.

4.2. Course redesign settings

The course redesign process is well documented in the literature and is often described as a series of stages or steps (forward or backward) or a revision cycle [22–24]. In the case of this project we work with DBR, as explained in the theoretical and methodological approach section. Although the different models of curriculum design differ in their emphasis on specific elements and their grouping of processes, the common elements of these models consist of: (a) information gathering, (b) reinvention of the curriculum, (c) implementation and d) evaluation of the effectiveness of reviews.

In this course, the information collection was carried out quantitatively with official evaluations of the course and mid-term surveys. With these data, improvement actions were implemented in the second semester of teaching the subject, optimizing the performance of the teachers and the academic performance of the students. Other proposals for improvement emerged in the second semester of teaching and are being implemented in the fall semester of 2020. The idea is that the redesign process is constantly active to guarantee the continuous improvement of the academic experience.

The improvement proposals consider 3 fundamental aspects: a) interaction with students, b) alignment of learning activities with real problem situations (academic challenge of the course), and c) use of technological tools.

a) *Interaction with students*: The use of Zoom Rooms allows the synchronous communication of the participants. However, when it is transmitted remotely, it presents a certain negative effect on the student-teacher contact; to correct this aspect the following proposals were presented:

1 Strengthen direct contact with students from remote campuses to foster engagement with the class: establish special contact sessions with students from every campus through Zoom and generate personalized asynchronous interactions through mail, instant messaging applications, forums and social networks.
2 Strengthen the figure of the facilitator within the model to replace the teacher in the RIC: hold weekly sessions prior to classes to review content and activities, as well as feedback sessions with the teaching team to learn about students' experience and generate participation and monitoring strategies.
3 Apply micro-teaching in class: thus, improving the dynamics of interaction with students, in such a way that different stimuli are presented at specific times, mixing theoretical exposure times with activities, activations and/or participations. Avoid presentations longer than 20 min.
4 Modify the guest's profile, giving preference to prominent young personalities who prioritize the connection of generational interests in addition to an extensive academic and / or professional curriculum. Interaction with guests is an attribute that is enhanced when they generate links with current and technological problems.

b) Alignment of learning activities with real problem situations. During the design of the course, learning activities related directly to real situations were included. To improve this aspect, it was proposed:

1 Update the cases of problematic situations and open a range of options according to the topics of interest to the students (example: environment, sustainability, gender perspective, ethnicity). In this way, students have the opportunity to explore and investigate in greater depth the topic that interests them the most.
2 Reduce or adapt the number of learning activities to the development of the evidence of competencies, so that the progress of the student's competences can be gradually observed.
3 Improve the evaluation mechanisms: revision of the wording of the instructions in a more explicit and specific way of the learning activities, avoiding wording in the form of questionnaires that limit the student's argumentative presentation and simplify the evaluation rubrics.

c) Greater use of technological tools to complement the teaching-learning process. During the first implementation it was observed that technological tools were underused, so it was considered:

1 To include rapid tests or exercises as part of the class dynamics, using various technological tools so that the level of knowledge of students can be determined before class and reinforcing the concepts learned.
2 The use of different technological tools to keep the class active.
3 Graphic redesign of the Canvas platform (educational platform for the course learning platform to facilitate understanding of content and activities).

Table 2
General data of the analyzed courses.

	Fall 2019	Spring 2020
# Students	109	48
# campus	5	5
Teaching team (number of teachers involved)	Professor 1 Tutor 3 Facilitator 5	Professor 1 Tutor 1 Facilitator 5

Table 3
. Midterm survey results. Students answered midterm surveys anonymously for the indicated semesters. The answers had a maximum of 10 points (totally satisfied) and a minimum of zero (totally dissatisfied). The standard deviation (SD) is indicated (+/-).

	Element to be evaluated	Fall 2019	SD +/-	Spring 2020	SD+/-
Learning experience with the Professor	Interaction and communication	7.60	2.52	9.00	1.70
	Academic advising	7.40	2.62	8.90	1.71
	Learning in class	7.80	2.46	8.80	1.67
	Dynamism and interaction in classes	7.40	2.62	9.10	1.51
Course Design	Amount of weekly activities	8.30	2.16	8.20	2.45
	Clarity in the instructions and evaluation rubric of the activities	7.70	2.49	8.70	2.10
General Experience	General learning experience (professor)	7.70	2.64	9.00	1.57
	General learning experience (tutor)	8.90	1.87	9.60	0.61

Table 4
Final survey Questions for the evaluation of Professors (ECOA). The answers had a maximum of 10 points (totally satisfied) and a minimum of zero (totally dissatisfied).The standard deviation (SD) is indicated (+/-).

Question	Description	Fall 2019	SD +/-	Spring 2020	SD +/-
1	The teacher shows mastery and experience on the topics subjects	9.07	1.50	9.45	1.16
2	The teacher challenged me to do my best (develop new skills, new concepts and ideas, think differently, etc.)	8.17	2.06	9.10	1.34
3	In general, my learning experience with the teacher was	8.02	2.31	9.33	1.17
4	The teacher promoted an environment of trust and respect	9.24	1.88	9.81	0.55
5	The support I received from my teacher was adequate (answers to questions, advice, feedback, etc.)	7.87	2.20	9.60	0.85

4.3. Technological tools to enrich teaching practice

The introduction of tools or applications that promote collaboration or interaction between students should be considered naturally in terms of new learning environments, fostering creativity and collaboration [25].

The modality in which the course is carried out implies the use of technology for its implementation. However, as part of the redesign proposal, emphasis was placed on complementing the teaching-learning process inside and outside the classroom with technological tools that encourage interactive participation with students and enrich the educational experience. For those carried out in the classroom, we have classified the tools into three sections: a) *participation*: which allows simultaneously generating participation in different campuses (Padlet, Speedwheel, Slido), b) *learning*: which allows validating or reinforcing knowledge (Socrative, Kahoot, Quizizz) and c) *remote interaction*: asynchronous discussion forums, Remind and/or Twitter.

Table 2.

4.4. Mid term satisfaction surveys results

As part of the improvement strategies and to learn about the students' experience, a mid-term perception survey was conducted. The objective of the survey was to identify opportunities for the improvement of the running course. The mid-term survey permitted the evaluation of students' experiences in the course based on two main areas: (1) the experience with the teacher (related to interaction and communication, academic advice, learning in sessions and dynamism and interaction in sessions) and (2) the design of the course (linked to the number of learning activities and clarity in the instructions and rubric to evaluate them). Finally, students rated their overall learning experience in terms of their teacher and tutor. In the 2019 fall semester, 67% of the students participated, by contrast, in the 2020 spring semester 94% took the survey. Table 3 shows the comparison of the results of both semesters.

The results show a clear increase in the level of satisfaction. A significant increase was observed with professor performance, most likely due to the redesign experience with the inclusion of reinforcing learning practices, use of technology to maintain an active class, as well as to generate greater interaction inside and outside the sessions with the teacher. Regarding the design of a new course, a favorable increase in activities is observed. Finally, in the general experience of the students, a significant increase (17%) is observed in

Table 5
Survey questions for the evaluation of tutor teachers.

Question	Description	Fall 2019	Spring 2020
1	In their feedback they provide complementary ideas, practical examples, or make comments of an academic nature that enrich your learning in the following way:	9.23	9.45
2	They motivate you to actively participate in the course in one way:	8.91	9.10
3	The respect they show in their communication is:	9.51	9.33
4	They Maintained constant and effective communication through the various means of interaction in a way:	9.34	9.81
5	Compliance with the times established in the course policies regarding the sending of feedback on learning activities (7 calendar days) is:	9.45	9.60
6	Compliance with the response times established for communication through email and / or advisory forums (1 business day) is:	9.17	9.76
7	Considering the aspects of feedback, motivation, communication, and punctuality, how do you evaluate the general performance of your tutor teacher?	9.25	9.71

Table 6
Weighting of each activity during Elite class. Five different activities were carried out in both courses, but the weight of each of them was evaluated and in some cases changed as stated.

	Fall 2019		Spring 2020	
	Amount	Weight (%)	Amount	Weight (%)
Written evidences	2	55	2	55
Quick exams	3	18	3	15
Homework activities (outside the class)	5	10	5	9
Class Activities	12	17	9	18
Class Participation	0	0	1	3
Total	22	100	20	100

the spring of 2020 compared to the previous period.

4.5. Results of the final opinion survey of TEC MTY

The Student Opinion Survey (ECOA) is an institutional evaluation instrument that students carry out at the end of each semester to evaluate their professor and the tutor on a voluntary and anonymous basis. In the case of the professor, the mastery and experience of the teacher in the subjects, the challenge level for the student, the environment in class (trust and respect), the accompaniment and the general evaluation of their learning experience are evaluated (Table 4).

In the Fall Semester of 2019, 55% of the students answered the ECOA survey, while in the Spring Semester of 2020 a participation of 88% was obtained (Table 4). Our results highlight a clear and significant increase in the results of the satisfaction survey in all the questions, with special attention to the support received by the teacher (+22%) and the general experience of the course (+16%). It is very likely that these results are a response to all the improvements applied in the spring 2020 course.

For the tutor, the quality of the feedback is evaluated, the motivation to participate actively in the course, the constant, effective and respectful communication, the response times in the feedback and communication and the general evaluation of their learning experience. The results presented in the final survey for the tutors are described in Table 5.

In this case we can see an increase in all ECOA results for the tutor as well. In particular, there is an 8% increase in motivation to participate in the course and in response times to meetings (+ 6%).

4.6. Results of general student performance

To strengthen the data that shows the improvement of the subject over time, the final results of the students in terms of final grade are presented: percentage of students approved and percentage of students with outstanding results or above 90 (out of 100). The improvements applied encouraged students' participation in the class and, therefore, their academic performance. The final grade was calculated directly from the Canvas platform (**Table 6**). The value of the evidence was maintained (55%) but the weight of the rest of the activities was redistributed, including a new class participation item for the Spring 2020 semester.

In the *Citizenship and Technology* class we work with 4 transversal Tec 21 competencies: *ethical and citizen commitment, reasoning of complexity, communication* and *digital transformation*. These competencies are connected with specialized sub-competencies. For the ethical and citizen commitment we developed two: *recognition and empathy* (respect for the dignity, rights, contributions and circumstances of others, trying to present constructive and supportive solutions to people's situations) and *citizen commitment for social transformation* (building committed, sustainable and solidary solutions to social problems and needs, through strategies that strengthen democracy and the common good). For complexity reasoning, we enhance *critical thinking* (evaluating the strength of our own and other people's reasoning, identifying the fallacies and contradictions that allow us to build knowledge). In relation to *communicative* competence, we develop a dialogic (construction of agreements and proposals through the exchange of arguments and emotions).

Table 7
Final results. Average final grades of students in both, 2019 Fall and 2020 Spring Semesters (Maximum 100). The percentage (%) of approved students (grades higher than 70), and students with grades higher than 90 are indicated.

	Fall 2019	Spring 2020
Final Grade	81.4	87.4
% Students approved	92%	100%
% Students with grades higher than 90	36%	40%

Finally, in relation to *digital transformation*, we work on digital culture (through conscious strategies that generate value for professional and personal participation in online society). These competencies are evaluated through specific activities related to situational problems of exclusion (evidence 1) and participation (evidence 2). During the fall of 2019, the group average in evidence 1 was 77/100 and in evidence 2 84/100. In the spring 2020 period, the group mean in evidence 1 was 84/100 and in evidence 2 it was 90/100. Finally, Table 7 shows the comparison between the two school periods, Fall 2019 and Spring 2020 in terms of final grade, with the percentage of approved students and the percentage of outstanding students. The data show an increase in all the items analyzed.

5. Conclusions

Designing Tec21 Model subjects in Elite class format represented a challenge and an opportunity for continuous learning that shed light on good practices to consider when implementing hybrid courses. The use of the DBR methodology allowed us to work on areas for improvement, not only in the presentation of learning activities and evidence, but also in the experience of an innovative model for students. The complexity of implementing a hybrid model in a technology-enhanced learning environment opens up new challenges and opportunities for the teaching-learning model, particularly after the COVID19 pandemic.

The results reported here show that a redesign based on quantitative information supported by the feedback provided by the students, allows the improvement of educational experience and student performance. We especially highlight the following findings: personalized attention via instant messaging and special contact sessions with students from each campus via Zoom; generate personalized knowledge, quick questionnaires during the teaching of the class that allow to explore the level of knowledge of the students prior to the class and reinforce the concepts learned; use of applications and digital platforms to reinforce content; dynamics of interaction in class that combine 20-minute expositions with group activities; guest profiles that prioritize outstanding young personalities who prioritize the connection of generational interests; alignment of assessable activities for compliance with competence evidence and improvement of evaluation mechanisms.

The quantitative data presented show improvements in all the items monitored. Mid-term surveys show 17% increases in overall student experience; the official evaluations, according to the indicator of general experience of the subject, showed increases of 16% and the final grades of the students, quantitatively demonstrate that the improvements implemented in the redesign positively impact the educational experience and student performance.

Author statement

Cintia Smith: conceptualization, writing original-draft, methodology, proyect administration. Karina Onofre-Martínez: conceptualization, investigation, writing original-draft. Monica F. Contrino: formal análisis, resources, visualization. Jorge Membrillo-Hernández: writing - review & editing, visualization, supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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