Study of the Effectiveness of Interactive Videos in Applied Electronics Courses

Graciano Dieck-Assad [1] *, Juan M Hinojosa-Olivares [1], Jordi Colomer-Farrarnos [2]

[1]Tecnologico de Monterrey, Ave. Eugenio Garza Sada 2501, Monterrey 64849, NL, Mexico
[2] Universidad de Barcelona, Gran Via de les Corts Catalanes 585, 08007 Barcelona, España

graciano.dieck.assad@tec.mx, juhinojo@tec.mx, jcolomerf@gmail.com

*The correspondence should be addressed to Dr. Graciano Dieck-Assad

Abstract

The use of interactive videos as an instructional technology tool is increasing in engineering education to provide a versatile and attractive learning environment for students and to interest them in course content to increase student engagement. This study assessed the effects of using interactive videos in undergraduate electrical engineering courses to enhance student understanding and engagement with electronics. To test the impact on learning outcomes with the interactive video methodology, we set up six controlled groups of students. The experimental groups were sections "A1," "B1," and "C1," in which a set of 13 customized short, interactive videos (15 minutes or less) were available through the course. In the controlled group sections "A," "B," and "C," the instruction was applied without videos. The final exam and overall grades were compared in all the sections to obtain an indication of the impact of the interactive videos. Also, we applied an exit survey to the students in the experimental sections to collect their opinions about their engagement, motivation, and commitment during the semester. In the experimental sections, a reasonable impact on the student final grades was found, with averages of 84, 80, and 83. The students' opinions about the interactive videos were very positive: from the standpoints of motivation, 90.4%; and understanding of class materials, 91.6%. Later, an additional section, "D," was studied and performed well in their video scores. The students having video scores above the class average had much better performance in their overall grade, with an average of 81.8%. Students from section "D" who did perform lower than the class average in their videos had lower overall performance, with an average grade of 76.5%. Moreover, additional videos were provided in the special "i-Week" activity during the fall semesters. The challenge activity put to the students during that week was "Emergency First Response," which allowed them to generate some technology proposals for first responders in the community; the students performed very well in the challenge proposed to them. Some insights about this project and the video methodology used in their instruction are described as part of the semester-long activity for the students. Finally, the students suggested additional interactive videos with more example problems to consolidate the hybrid interactive video learning methodology. The interactive video technology is fully considered in the TEC21 Educative Model that governs the new degree programs beginning in 2019 at Tecnologico de Monterrey.

Keywords

Higher education, electronics, interactive videos, hybrid learning, educational innovation

1. Introduction

The learning strategy proposed for electronics courses in this research integrates four active elements into the student environment: interactive expositions, device simulation exercises, demonstrations using interactive videos or screencasts, and an interactive working platform. The lack of student retention of fundamental concepts in key electrical engineering courses led us to the development of this strategy; we had observed that the students' attention vanishes due to a number of great distractors. Recent investigations show that learning enhancement and engagement and commitment of students increase when video technology is added as an instructional strategy [1 - 6]. Also, the inclusion of an interactive strategy has provided additional reinforcement-and-review alternatives to the students [7]. The flipped classroom teaching strategy [8] provides additional learning features and can facilitate a complete integration where the videos are the central technological tool.

Comprehensive software platforms [9] for video editing and teacher/student interactions are readily available to faculty. Some implementations of video interactions using this tool have been reported [10] for Physics and Mathematics courses. However, other engineering fields also have explored the inclusion of more video technology in their learning strategies. The interactive videos used in the present study were developed using several technological platforms available for higher education [9, 11, 12].

This paper reports the results of an initial study of the impact of using interactive videos in Science and Engineering courses at Tecnologico de Monterrey. Some of the major contributions highlighted in this paper are:

- We describe a methodology to investigate the effectiveness of interactive videos in Electronics Engineering courses at the Tecnologico de Monterrey on the Monterrey campus. (There are 26 campuses throughout Mexico.)
- The study addresses both the overall understanding of the topics in the course content by the students and their level of engagement with the content.
- The study uses results from two groups: the experimental sections that offered 13 optional interactive videos throughout the semester and the other sections, where the students received traditional instruction without the use of videos.
- Although this preliminary study shows a modest impact on the results of the final exams and final overall grade in the sections where the videos were used, it also shows very favorable student engagement. We analyzed exit polls given to all the students where the interactive videos were available. These results were that 90.4% of the students in the sections where the videos were available expressed overwhelmingly that their motivation and understanding of the class topics were enhanced by using the interactive videos.
- Also, 77% of the students believed that they were stimulated about the topics through the videos.
- The integration of video technology into the i-week project, "Emergency First Response," had good results.
- The interactive video technology is fully considered in the adoption of Challenged Based Learning (CBL) in the new Tec21 Educative Model for degree programs beginning in 2019 at the Tecnologico de Monterrey.

Our paper provides a description of the methodology used and the results obtained in this study. Interactive videos are part of the learning strategies repertoire for the new degree programs at Tecnologico de Monterrey starting in the Fall of 2019.

2. Problem Description

During the last 10 years, the engineering students have oriented their learning process towards professional outcomes and acquisition of competencies. University teaching includes different conceptual, procedural, and value content at different levels of science and engineering. However, the purely traditional class exposition has been questioned due to:

a. Lack of student interest in certain non-dominant courses within their major study program.
b. Specific distractors such as cellphones and portable computing equipment like tablets, notebooks, and other mobile gadgets.
c. Student boredom with specific exposition styles of the teacher, leading to lack of motivation and interest.
d. Excess of activities and other work responsibilities that the student is immersed in during his/her university experience.
e. Mismatch in student learning style versus professor teaching style, and a lack of communication between professor and students. This is worse when the class is not taught in the student's native language.

Previous Background

From all the various learning tools, procedures, and strategies, the new generation of students has adopted, as a daily activity, using a wide variety of illustrative videos that provide a huge amount of information and communication coming from many different levels of individuals and communities. The student sees videos as a natural gateway to the acquisition of knowledge and competencies in our modern world.

VideoTube, YouTube, Google, and other web tools have noted the students' interests and have responded by providing large amounts of information, from both reliable and questionable sources.

During the Fall 2015 semester, a group of professors was organized to take a workshop [10, 11] that described and explained in detail some of the very flexible techniques and tools to develop, organize and edit high-quality interactive videos. Using some readily available software tools [9, 11, 12, 13], the Electrical and Computer Engineering (ECE) faculty developed interactive videos for courses taught in the fall and spring semesters of 2016 and 2017, respectively. What is needed now is an effectiveness study to understand what would motivate additional faculty to take up this interactive video teaching strategy in different fields of engineering.

Problem Relevance and Objectives

The ECE faculty discussed the desirable competencies and outcomes with employers in different areas of electrical engineering. The employers recommended that teaching provide more emphasis on the fundamental concepts in distinct professional programs, especially for the new generation of engineering students. At National Instruments [12], during a recent interview with engineers, the need to strengthen the fundamental engineering science and design knowledge among engineering students of different majors was established. Engineering majors in areas such as electronics, robotics, mechatronics, and electromechanical require solid work and development opportunities at the global level. Using interactive videos which provide additional elements to the hybrid educational environment may enrich and enhance content instruction and student learning with the following characteristics:

i. Reinforce fundamental knowledge in areas of engineering.
ii. Use alternative technologies to combine simulations, videos, quick experiments, and interactive expositions so that the instructor can motivate students and increase their participation, engagement, commitment, and sense of responsibility.
iii. Achieve desirable outcomes in knowledge acquisition of the complicated, conceptual contents using interactive videos. This way, students engage in their courses continuously.

For education professionals, an effectiveness study of the use of interactive videos in higher education could quantify relevant indicators such as:

1. The increment of students´ learning levels of conceptual contents.
2. An “engagement” indicator for the student with respect to his/her interest in the course.
3. The degree of differentiation when using the interactive video methodologies compared to other traditional teaching-learning methods.
4. The multidisciplinary viewpoint of the hybrid learning methods which include strategies such as interactive exposition, interactive videos, quick experiments, simulation experiments, and innovative learning platforms.
5. The integration of university focus groups to promote new models and best practices in the search for multidisciplinary solutions for university faculty.

Problem Formulation

What is the effectiveness of interactive videos for undergraduate students in their professional specialty courses? How do we promote the “engagement” and commitment of the students in undergraduate courses to their professional development of outcomes and competences?

The main objective is to determine the effectiveness level in the learning process and the “engagement” of the students when the interactive videos are used in applied electronics courses. This preliminary study provides the initial step to the implementation of alternative learning strategies for the Tec21 [14] degree plans starting in the Fall of 2019. The specific objectives are:

a. Quantify the global student performance with and without the interactive videos for the applied electronics class.
b. Determine the “engagement” level (satisfaction with the learning developed concepts) by the students.
c. Compare the student´s performance in several controlled sections; some with interactive videos and others without them.

Justification

Research in education has shown studies of effectiveness when using videos at the undergraduate level with focuses on specific disciplines such as nursing and health sciences [1]. However, the need for more multidisciplinary studies where a course is being offered to multiple groups of majors is necessary and has not been

discussed. Also, the use of interaction in short videos to address specific concepts has not been analyzed in terms of the elements, *effectiveness of learning*, and *engagement*. So far, there have been learning strategy studies published that show that videos have a significant impact on "engagement" and commitment [1, 2].
However, studies that differentiate between interactive videos and other technologies have not been seen. In the interactive videos, the students are exposed to the concept in a short video, and he/she answers questions, reviews the material, and gives a review of the "just seen material" in the same screencast. Moreover, studies of interactive video´s effectiveness are not available with results and discussions for courses in science and engineering. This paper intends to provide an initial step in resolving that problem by reviewing the results of interactive video effectiveness in the multidisciplinary engineering groups in the Applied Electronics course taken by engineering majors in the different areas of electronics, robotics, biomedical, and mechatronics.

3. Methodology

During the last 5 years, the use of videos in the teaching-learning process has been intensified, and researchers have developed studies to determine how effective they are in the acquisition of competencies by students. Lancaster [15] and Petty [16] did studies about the impact on grades in courses when the additional video ingredient is added to the tool repertory. They focused on courses in nursing and health sciences. Ford [17], McGarr [18], and Mullanphy [2] developed studies about student satisfaction when they are exposed to technological tools such as videos in their courses. Anisimova and Krasnova [19] had significant results using interactive technologies to increase the competitiveness of undergraduate students pursuing a bachelor's degree in electronics. Finally, Lai [20] investigated and determined three key factors to adopting new technologies like videos: a) educational compatibility, the degree to which the students perceive the innovation with respect to the existing values; b) simplicity in adoption, or the degree of perceived support available by the students in their environment; and, c) attitude towards the use of technology, or the degree in which the individual establishes a positive or negative sense of technology.

All those studies illustrate the impact in courses of specific areas, and they have not gone beyond the disciplinary aspects of a particular profession such as nursing or health sciences. Also, the studies do not differentiate the effects of using the "flat video" (just the screencast itself without interaction from the viewer) versus the interactive video, which allows the viewer to have continuous interaction. The interactive video provides a comprehensive process where students can review, reflect, ask questions, hear instructor comments, and receive feedback from instructors.

This research differentiates itself from previous studies by trying to answer these fundamental questions:

1. Is there any noticeable difference of impact on learning outcomes between the use of short, interactive videos compared to "flat" videos that show only the instructor talking without interactions with the student viewers?
2. What is the effect of this augmented tool (interactive video) on the student´s performance?
3. How do students engage themselves in the course content to promote their own learning when there is the addition of interactive videos as a technological aid?

4. What is the effect of using interactive videos among the different engineering fields studied, i.e., electrical, biomedical, robotics, and biomedical engineering?

Education research methodology.

The research methodology contemplated the Applied Electronics course with two different section groups. Groups with sections “A” (spring 2016), “B” (fall 2016) and “C” (fall 2017) did not receive the support from the videos, and groups with sections “A1” (spring 2016), “C1” (fall 2016), and “D1” (spring 2017) did receive the additional support of the interactive video tools throughout the semester. The measurement of knowledge acquisition came from the results of two partial exams and a final exam where learning outcomes were tested. The student commitment/engagement factor was evaluated using exit surveys given to the students in the group having interactive videos available Figure 1 shows the methodology.

The instructor in charge of sections “A1,” “B1,” and “C1” developed the videos using the Screencast-O-Matic [11] and EDPuzzle [9] platforms with the following restrictions:

a. The interactive videos will not be longer than 15 minutes.
b. The short videos discuss relatively complicated concepts for the students according to the previous experiences of the electronics´ instructional team.
c. The short videos include some examples of design problems.

The instructor developed the videos during the winter 2015 and summer 2016, which involved some significant initial effort. For instance, a single video took an average of 3 to 4 hours to record and produce. However, they are re-usable in several sections, and so far, we have had six semesters in applying the technique with successful results.

4. Course Specifications

The Applied Electronics subject is a comprehensive, application-oriented course for undergraduate, Junior-year engineering students majoring in electronics, mechatronics, biomedical, or other broad-background engineering disciplines. The course covers the following topics: basic models of operational amplifiers (op-amps), basic configurations and analyses of op-amps, linear signal conditioning op-amp applications, static and dynamic limitations of real op-amps, non-linear circuits using op-amps, and signal conversion D to A and A to D. The course serves as a preview for Capstone projects and development of term projects undertaken by students during their Senior year. Also, this course helps to link digital and analog electronics when they develop a term project for the class. The short, interactive videos developed for the applied electronic class are:

1. Facts about Analog Integrated Circuits Design.
2. Term Project Description.
3. Analysis of the Instrumentation amplifier.
4. Linear signal conditioning V to V amplifiers.
5. Linear signal conditioning V to I amplifiers.
6. Linear signal conditioning I to V amplifiers.
7. First Order Active filters.
8. Second-Order Low and High Pass Filters.
9. Second-Order Band-Pass and Notch Filters.

10. Precision rectifier circuits.
11. Precision full-wave rectifier circuit (FWR).
12. Sample and Hold amplifier (SHA).
13. Sinewave Oscillator circuits.

The group sections for the study are described in Table I.

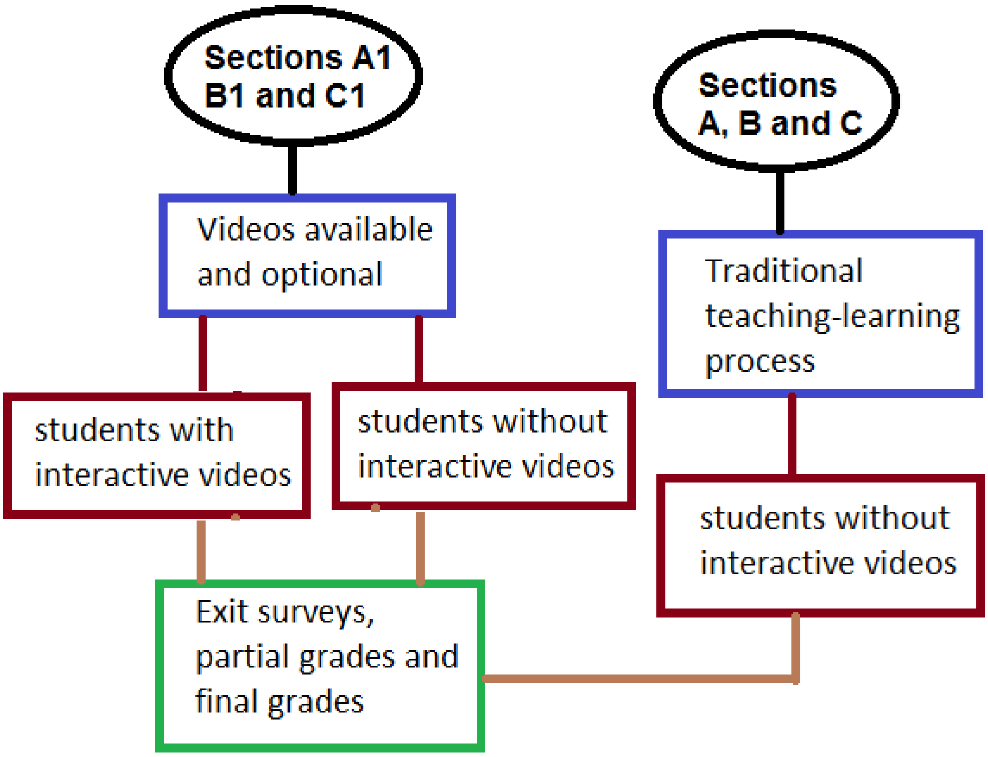

Figure 1. The methodology used in the various course sections.

Table I: Control sections

Group	Number of students	Partial exams	Final Exam	Term Project/projects	Interactive videos available
A	17	2	1	Yes	No
B	17	2	1	Yes	No
C	27	2	1	Yes	No
A1	16	2	1	Yes	Yes, 13
B1	34	2	1	Yes	Yes, 13
C1	37	2	1	Yes	Yes, 13
D	30	2	1	Yes	Yes, 13

5. The Innovation Week (i-Week)

The Tecnologico de Monterrey took an important step toward the development of an innovative learning strategy that creates strong ties between students and their communities, both nationally and internationally. In the seventh week of the fall semesters (2015, 2016, 2017 and 2018), all undergraduate students from the 2nd through the 9th semester of study selected a Capstone project which allowed them to develop high-value activities that foster the analysis, implementation, and the creation of concepts that would be very difficult to do in the classroom. (In 2019, this activity takes place in the 12th week.) In addition, the project develops the students' skills in interactions with real-world organizations and institutions.
Figure 2 shows the generic fall timeline. In the real-world scenario, students interacted with industry professionals, government officials, health care specialists, humanists, cultural developers, social workers, and others, to propose procedures and become active in the process of transforming ideas to solutions in their communities. On the Monterrey campus, a total of more than 13,000 students participated in this i-Week (in Spanish: *Semana-I* and for the Tec21 degree programs will be called *Semana-TEC* or *TEC-week* that takes place the 6th or 12th week of the semester at different places in Mexico and abroad). The video methodology was also implemented with the students who selected the Capstone project called Emergency First Response (EFR) [21] that was developed in collaboration with academic, governmental, and industrial groups in Mexico, including a) EIC (School of Engineering and Sciences at TEC); b) EGADE (Graduate School of Management and Business Administration at TEC); c) Health Department at the State of Nuevo León (SSNL); d) National Center for Accident Prevention in Mexico (CENAPRA) [22]; e) Ternium in Monterrey (TERNIUM), and f) Solvay in Monterrey (SOLVAY).

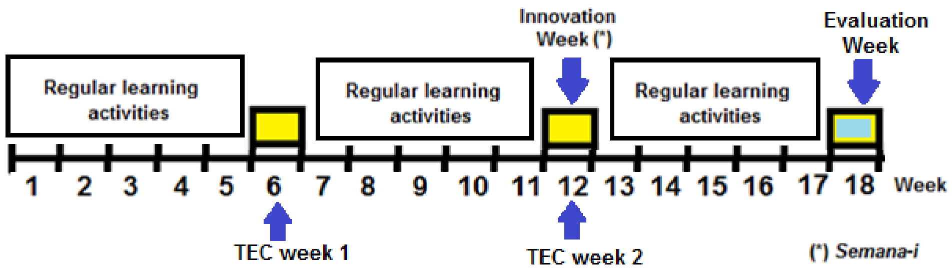

Figure 2. Fall Semester timeline at Tecnologico de Monterrey.

The Emergency First Response (EFR) Project

There are several training courses for first responders around the world. However, most of these courses are offered to people pursuing a professional life as law enforcement officers, paramedics, emergency responders, or firefighters. Such first responder courses are provided by community colleges and/or on-line education institutions such as Kaplan University, ITT Technical Institute, or Azusa Pacific University. These programs are also promoted to people who "most likely" will be the first on the scene of a medical emergency or work far from medical assistance such as search and rescue volunteers in rural areas, park rangers, lifeguards, teachers, and security guards. Upon completion of a first responder course, individuals earn a certification that is valid for two years. In order to maintain certification, first responders must take biennial refresher courses. The certification is granted by the National Registry of Emergency Medical Technicians (NREMT).

However, there are very few documented initiatives for creating a community conscience of first responders [23], even though the evidence has shown that when an emergency or disaster strikes, victims and volunteers truly act as the first responders. Take, for example, the following major disasters: several earthquakes that struck Mexico City in 1985 and 2017, the tornados in central Florida in 1988, and the hurricanes in Louisiana (2012), Florida (2017), and Puerto Rico (2017). In all cases, ad-hoc citizen groups self-organized to rescue other people from the rubble, and they created disaster relief centers, among other emergency response activities.

The EFR project fosters the student and faculty participation [24, 25, 26, 27] with the Government Health Administration in serving as First Respondents and even more, to promote training and collaboration using Information Technologies and apps to disseminate first-aid response in emergency situations. The training consists of a First Respondent workshop that provides competencies in first aid response, basic medical attention, and evaluation of emergency contingencies to provide assistance to individuals who have suffered accidents or sudden illness while awaiting the paramedics or medical specialists to arrive on the scene. The participating students were sophomores, juniors, and seniors from most of the undergraduate programs in engineering (Computer Science, Information Technologies, Electrical, Civil, Industrial, Chemical, Mechanical, Biomedical, Nanotechnology and Chemical Sciences, Mechatronics, Biotechnology, and Musical Production) and the business, humanities and social sciences programs (Business Management, Psychology, Architect, Digital Art, Nutrition, Law, Marketing, Economics, International Business, Journalism, and Communications). Faculty from Computer Science (CS), Electrical and Computer Engineering (ECE), and Information Systems (IS) participated in the project as coaches, mentors, and instructors during the i-Week. The participation of engineering majors from all disciplines, business administration majors, social science majors, other students from other disciplines, faculty from CS, ECE, and IS generates a fertile multidisciplinary atmosphere to produce innovative proposals for institutions and organizations.

Conceptual Contents and Interactive Videos

The basic conceptual contents of the first respondent workshop are:

1. Accident scene evaluation
2. Victims evaluation
3. Choking maneuver
4. Cardio-Pulmonary Resuscitation (CPR).
5. Wounds, burns, fractures, and convulsions.
6. Bandages, immobilization, and proper movement of victims.
7. Symptoms of principal illnesses, risks, and preventative measures.

The workshop includes practical exercises with mannequins and other materials provided by the Health Department. Particularly, the CPR and Choking maneuver training are emphasized and practiced so that the trainees develop the skills and competencies for CENAPRA certification. Moreover, the participating candidates must pass an exam on theory in order to be certified by CENAPRA.

The interactive videos used during the week were:

I. Scene Evaluation: Dangerous Real-Life Cases.

II. Heimlich Maneuver for Adults.
III. Choking Maneuver for Babies.
IV. CPR (Cardio-Pulmonary-Respiratory) Maneuver for Adults.
V. Basic Elements of CPR.
VI. CPR for babies.
VII. CPR using AED (automatic external defibrillator).
VIII. First aid for wounds and bleeding.
IX. Bandages and immobilization.
X. Moving and dragging a victim.

Capstone Activities

A Capstone activity consolidates the student collaborative work during the i-Week for the EFR project: Integration Tool or Proposal to support First Responders. In 2017, after the earthquake in Mexico City, an additional activity was performed where the students designed a Health Care Emergency Kit oriented for social organizations, educational institutions, enterprises, offices, commercial outfits, and sports clubs. The institution must be aware of the Capstone effort and will receive the final product of the design.

The Integration Tool or Proposal consists of the design and implementation of a procedure, technique, app or method to support education and training in first respondent skills and participation in the community. Teams of 5 to 6 persons develop the procedures, specifications, and necessary information to create the tool or app product. Some of the specifications for a reasonable proposal for a practical tool are:

1. The tool must be proposed to an educational institution, service provider, business, company, or even the administration of the state health care department.
2. The main idea is to be creative and innovative in integrating acquired knowledge to propose a useful, informative, serviceable, interactive tool or app that can educate, train, or make more skillful a specified population who could be First Responders in medical emergency situations.
3. The tool for emergency response should be selected to support users and workers in the prevention and servicing of medical emergencies at their facilities.
4. A presentation about the final activity could include a video or an app, and all the team members must be available for the question and answer section of the plenary session.

The evaluation rubric for the product includes the following: The designed tool fulfills the goal of informing and educating about medical emergencies, the selected institution and organization exists, the intended recipient of the tool is willing to use the application, and the proposed product of the project is practical, easy to use and innovative.

Outcomes and Evaluation

The competency development and desired outcomes for the students include:

a. Citizenship participation.
b. Collaborative work to propose solutions in multidisciplinary projects.
c. The ability to use information technology (IT) tools and have basic programming skills to develop useful tools or methods for first responders.
d. Certification from CENAPRA.

The certification from CENAPRA is obtained by:

a. A successful observation and evaluation by instructors of the student in a practice of accident scene evaluation, shocking maneuver, CPR procedures, and good practices in bandaging and proper movement of victims (lifting, dragging, carrying).
b. A successful passing of the certification exam (80% minimum grade) from CENAPRA.

The percentage weights of the final evaluation were 50% student attendance and performance, 20% CENAPRA certification, 20% Capstone project, and 10% final oral presentation.

First Responder Certification

The EFR project has provided significant growth in first responder certification since its inception in September 2015. So far, 764 responders have been certified, which gives a rate of 25 certified responders per month in the period from September 2015 through September 2018.

Table II: First Responder Certifications by CENAPRA 2015, 2016, 2017 and 2018

YEAR	Students	EFR Professors	Other Professors/Collaborators
2015	182	23	12
2016	198	4	22
2017	175	1	0
2018	209	7	0
Totals	764	35	24

While certifications occurred, the interactions between professors and collaborators also developed successfully. The external institutions SSNL, TERNIUM, and SOLVAY, and the EFR faculty had some organizational meetings for planning, reviewing, and rehearsal sessions during the year. Even Physical Education faculty and Healthcare campus representatives were involved in the process of training and certifications. The interaction among all the participating departments was very fluid; continuous meetings and feedback continued before, during, and after the i-Week [21].

Table III illustrates a summary of the schedule of EFR at Tecnologico de Monterrey during the i-Week in the fall semester of 2018. The schedule included three morning sessions of plenary seminar instruction where most of the theory was expounded. Days 2 and 3 included practice and drill exercises for the most important maneuvers (Choking and CPR), bandages and victim dragging. One day was also dedicated to a plenary session for an industry representative who gave a lecture about industrial security and medical assistance. Day 4 included a review of the theoretical concepts in preparation for the certification exam. Day 5 included project presentations and evaluations. Also, on that day, participants took the certification exam.

Representative Projects and Successful Proposals

The diversity in the students' disciplines resulted in innovative projects with a wide variety of ideas for both multidisciplinary innovations and product prototypes. A total of 764 students enrolled in the first respondent project since 2015 have elaborated about 120 different innovative project proposals. Different media products were the outcomes of innovation projects. The media products were mobile applications, posters, workshops, and banners at the metro station, etc. An important characteristic of all the projects is their link with an institution or organization as a client. The students contacted government dependencies, social groups, businesses, and industrial associations. The interaction with these institutions was a key opportunity to justify the novelty of the proposed innovations. The government dependency, SSNL, was very enthusiastic about the proposals [22]. TERNIUM and SOLVAY were also very positive about promoting the proposals. GEOVISIBLE (a TEC alumni business) expressed their interest in participating in the project in 2015, and they gave a presentation in 2016 about an application to help first responders [28]. This company initiated a spin-off based upon the ideas of Emergency First Response.

Table III. EFR 2018 Schedule during the i-Week.

	Monday 24	Tuesday 25	Wednesday 26	Thursday 27	Friday 28
9 AM	Registration and Take off	Fractures, immobilization, and dragging	RCP, Cardio-Pulmonar Reanimation	Presentation and use of the AED (Automatic External Defibrillator)	Team presentations in classrooms
10 AM	Motivation and preparation	Dismays, recuperation posture	Wounds, burns, bandages and convulsions	New recommendations for RCP From AHA (American Heart Association)	Team presentations in classrooms
11 AM	Scene Evaluation	Workshop QPR "Question, Persuade and Refer"	Wounds, burns and convulsions	bandage practice, evaluation of Heimlich and RCP	Presentations of the better evaluated teams
12 PM	Heimlich Maneuver	Workshop QPR "Question, Persuade and Refer"	Practice and evaluation of RCP and Heimlich	Review and description of presentation logistics and procedures	Presentations of the better evaluated teams
2:30 PM	Team formation and Scene Evaluation Practice	Practice of immobilization, dragging and Heimlich	Practice and evaluation of RCP and Heimlich	Development of integrative activities…by teams	Evaluation and individual certification exam
3:30 PM	Initiation: Projects EFR-f…by teams	Continuation of integrative activities…by teams	Continuation of integrative activities…by teams	Continuation of integrative activities…by teams	Diploma delivery and Closure

The innovation projects focused on three specific groups; namely, assisting, training, and raising awareness about first responders. In the awareness group, the common goal was to promote consciousness about the importance and need to have the first responders in the communities. Examples of innovative ideas in awareness were the elaboration of media and the proposals of guidelines to organize promotional campaigns at universities and high schools; the media and guidelines to organize run-and-walk events; the proposal of a law to call for restaurants to have first-responder-certified employees and to display posters with choking maneuvers; and the elaboration of media that takes advantage of the curiosity-shame nature of people to realize the need for first responders.

In the second group, the common project goal was to assist the first responders in how to react under an emergency and how to reduce response times. Examples of innovative ideas involved the development of mobile apps with features such as guiding the first responder in real-time with specific step-by-step instructions; incorporating voice commands for faster response; incorporating an option for direct emergency calls; rapid access to key maneuvering data; tracking the location of an accident; incorporating a database with the current location of first responders; support for scene studies to avoid risks; and tracking the path and arrival time of the ambulances.

The projects in the third group had the goal of educating/training first responders using different types of media. Several projects naturally combined the education and the awareness categories together. Educational projects covered common contingencies such as cardiopulmonary resuscitation, burns, choking, convulsions, wounds, strokes, etc. The educational projects also considered instruction about maneuvers for different environments such as home, social, club, gym, school, business, and others. Examples of innovative ideas for first-responder education were the elaboration of first-responder complementary materials with illustrations and concise instructions; elaboration of first-responder educational materials with specific emphasis on babies; a training program specific to rural areas and medically underserved communities; mobile phone content to reinforce the knowledge about the cardiopulmonary resuscitation procedures; an elective course about first responders in high schools; tools for fast location of first-responder training and educational materials; an instructional program that integrates books, videos, web sites, and workshops; teaching awareness of ineffective, traditional medicine remedies and their medically-acceptable counterpart treatments; interactive guides, video games to strengthen the knowledge about CPR, specialized cabins for community/university campus, short movies, intelligent electronic gadgets, and training games and gadgets to practice the first response maneuvers.

The development of other specific accessory equipment was assigned to more advanced students who design first responder devices such as shields (clear mouth barriers for artificial ventilation systems) or rescue-masks for CPR procedures [29]. Also, the interaction among students from the Electrical Engineering, Computer Science and Information Technologies areas (similar to Engineering Clinics) [30], the development of technology-driven applications [31], and the participation of companies [32] provide a very fertile, multidisciplinary environment that promotes innovation and new business opportunities. Right now, a spin-off entrepreneurship project about medical emergency training for schools and social organizations is being developed by two students who took the workshop in 2017 [33].

6. Results

This study shows results for the correlations between the video scores and final grades, and the degree of student engagement. The video scores are obtained by grading the interactive questions answered by students during the process of watching the video. The final grades are obtained from weighting the two partial exams, self-study activities, quick experiment grades, and the final exam during the course. The degree of engagement was obtained immediately after the students completed their final course activities by responding to the exit survey. The results were compared in two groups I and II. Group I compares sections “A” and “A1” (spring 2016). Group II compares sections “A” (spring 2016), “B” (fall 2016), “C” (fall 2017), “A1” (fall 2016), and “B1” (spring 2017). Sections “A1” (16 students), “B1” (34 students), “C1” (37 students) and “D” (30 students) answered the exit poll, and the results were analyzed as feedback to decide about the continuation of the interactive video strategy at the ECE and other engineering departments.

Sections “A,” “B,” and “C” did not use interactive videos during the semester; those sections had 17, 17, and 27 students, respectively. Figures 3, 4 and 5 show the final course grades for those sections with no-videos available. Their final grade averages were 70, 76, and 79, respectively.

The initial comparative results were obtained from sections “A” and “A1” during the spring of 2016. The impact of the interactive videos in section “A1” is illustrated in Figures 6, 7 and 8. Figure 6 illustrates the final grades for the course and the video performance scores for the 16 students in section “A1”. The figure shows that 2 of the 16 students fell behind, having poor video performance scores and final grades lower than 40. However, very good video performance scores were reflected in at least 5 out of 16 (31%) students from section “A1”. Figure 7 shows the final grades of students who obtained higher grades (>52, which was the mean value of video scores) for the interactive videos. Figure 8 shows the final grades for students who obtained lower grades (<52) for their interactive video performances. Group I results from Figures 3, 5, and 6 are summarized in Table IV. Table IV shows that students from section “A1” who performed relatively well in their video scores had a much better performance in their overall grade, with an average of 84 and a standard deviation of 8 (less dispersion). Students from group “A1” who did not perform very well in their video scores had a lower performance in their overall grade with an average of 67 and a standard deviation of 21 (more dispersion). Students from section “A” did get an average performance of 70 in their final grades with a standard deviation of 15.

Even though these results show some influence of the interactive videos, a larger sample and more testing were performed in additional sections: “B,” “C,” “B1,” “C1,” and “D.” They were tested in the fall 2016 (sections “B” and “B1”), in the spring 2017 (section “C1”), in the fall 2017 (section “C”), and in the spring of 2018 (section “D”). Results for section “B1” having 34 students, Figure 9, show the final grades of students who obtained higher grades (>76.67, which was the mean value of video scores) for the interactive videos. Also, Figure 10 shows the final grades for students who obtained lower grades (<76.67) for their interactive video performances.

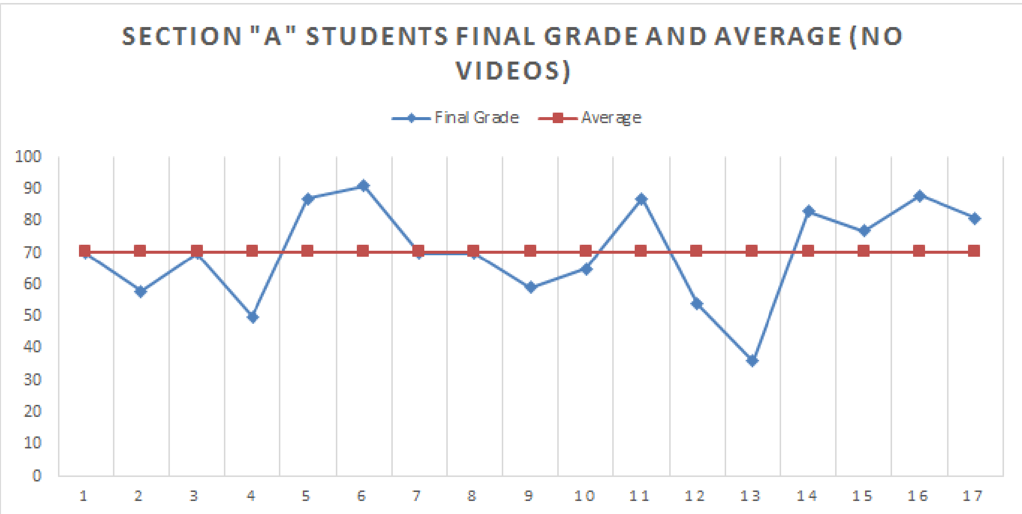

Figure 3: Final Grades and Average, section “A” students.

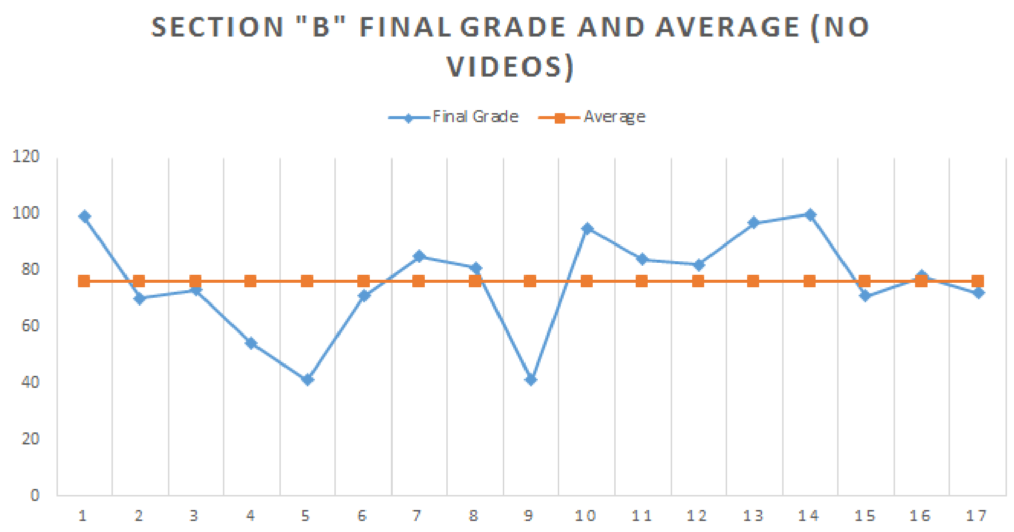

Figure 4: Final Grades and Average, section “B” students.

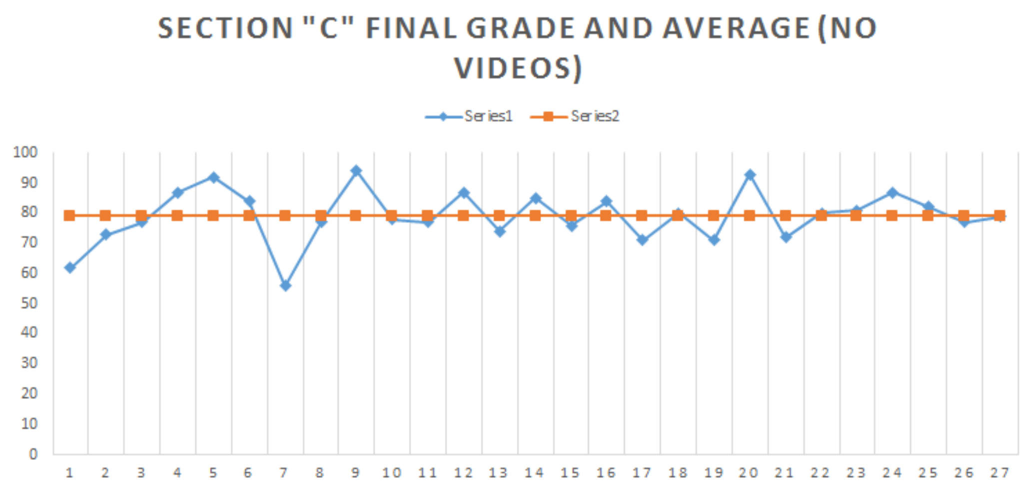

Figure 5: Final Grades and Average, section “C” students.

Table IV: Comparison Group I: Controlled sections A and A1

Section	Number of students	Video scores	Interactive Videos available	Average Final Grades	Standard Deviation
A	17	NA	No	70	15
A1	9	>52	Yes	84	8
A1	7	<52	Yes	67	21

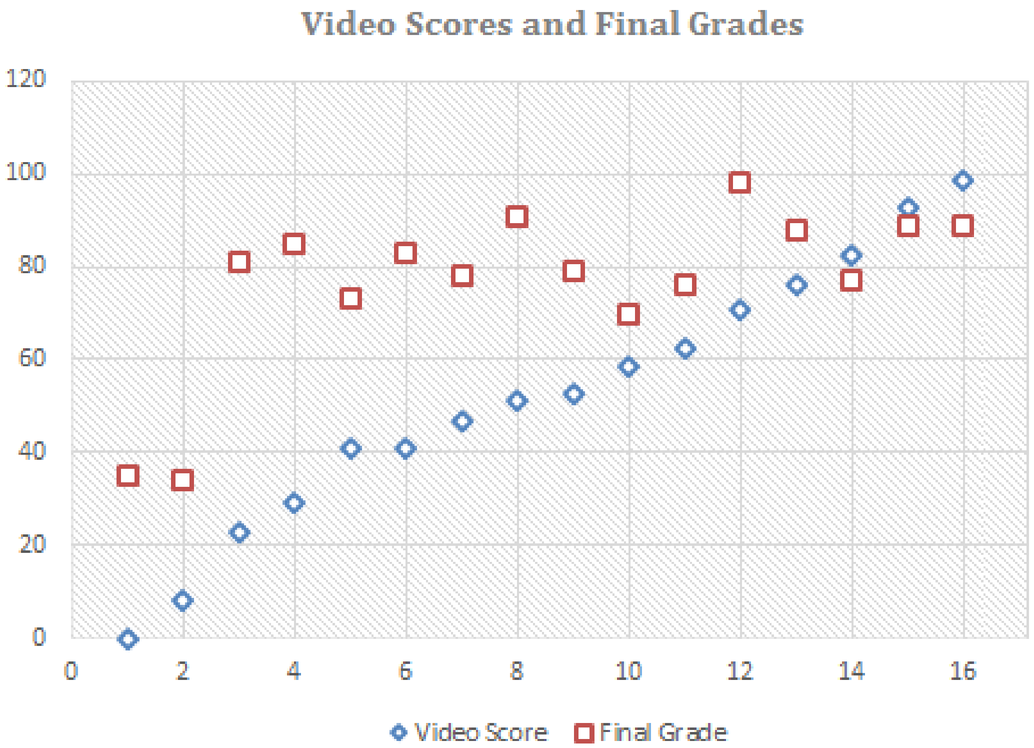

Figure 6: Interactive video scores and overall final grades for students in section “A1”.

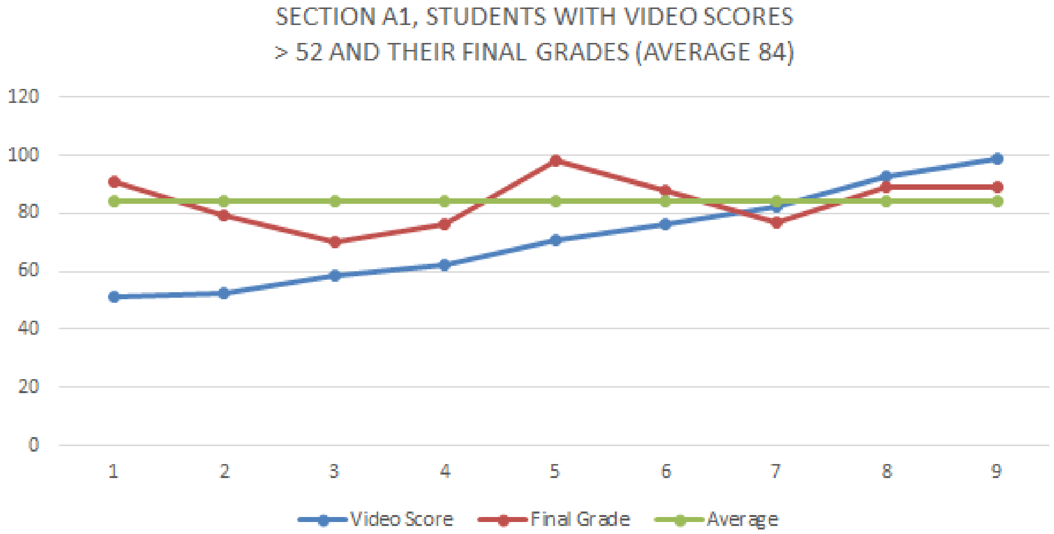

Figure 7: Final overall grades for students from section “A1,” who obtained high video scores (>52).

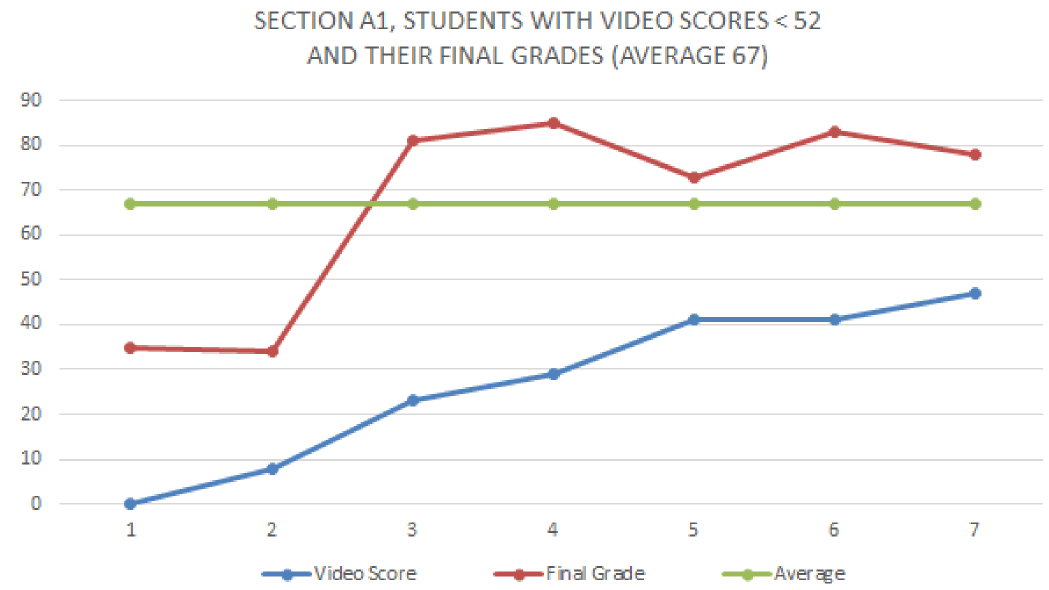

Figure 8: Final overall grades for students from section “A1,” who obtained low video scores (<52).

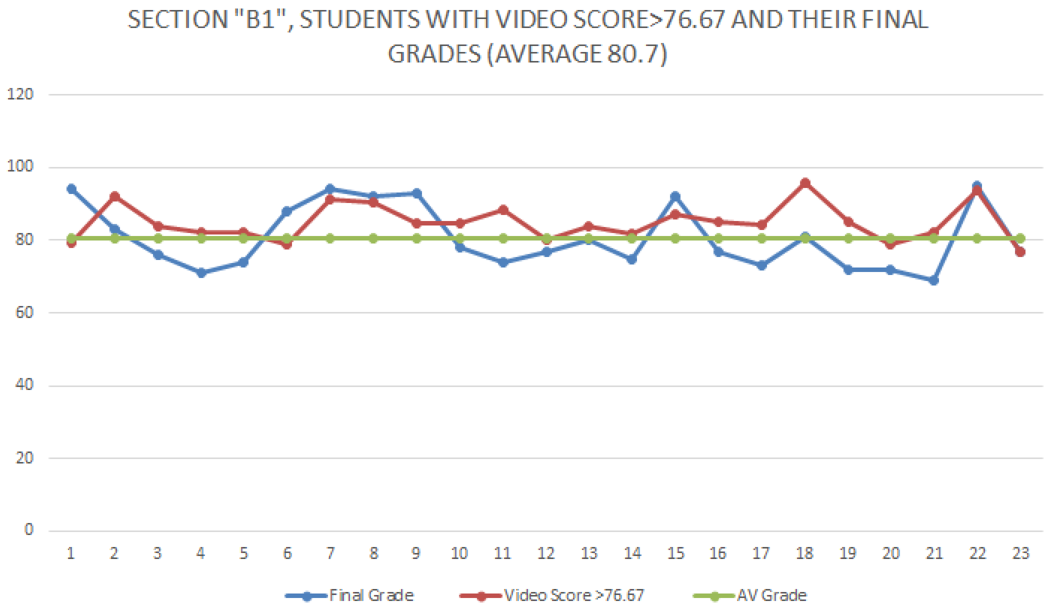

Figure 9: Final overall grades for students from section “B1,” who obtained high video scores (>76.67).

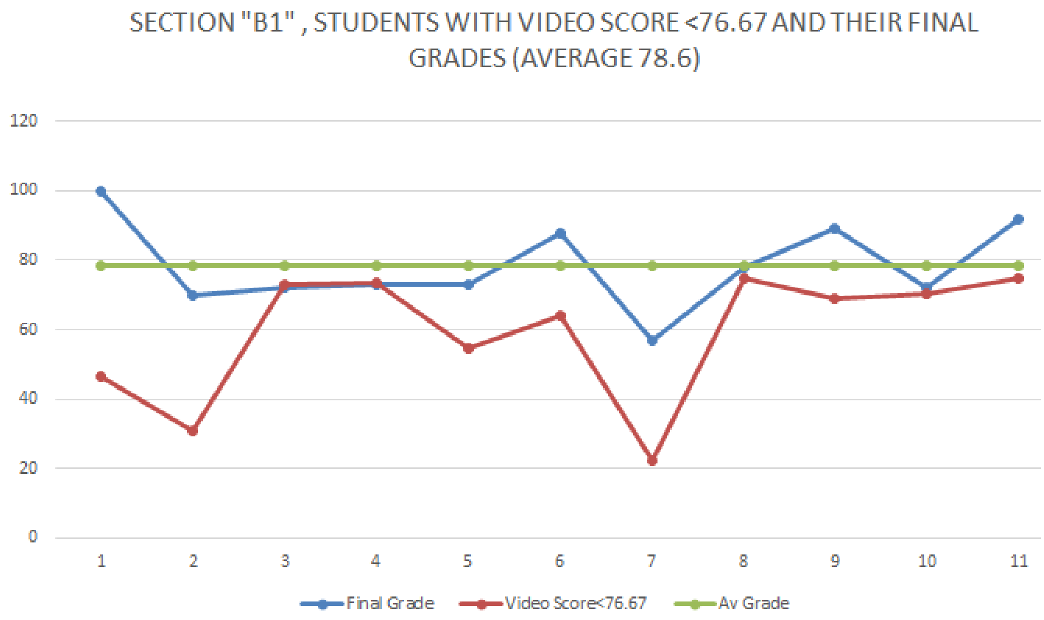

Figure 10: Final overall grades for students from section “B1,” who obtained low video scores (<76.67).

Results for section “C1” (spring 2017) having 37 students, Figure 11, show the final grades of students who obtained higher grades (>47.07, which was the mean value of video scores) for the interactive videos. Also, Figure 12 shows the final grades for students who obtained lower grades (<47.07) for their interactive video performances. Group II results from figures 3, 4, 5, 9, 10, 11 and 12 are summarized in Table V. Table V shows that students from sections “A1,” “B1,” and “C1,” who performed relatively well in their video scores (having scores above the class average), had a much better performance in their overall grades with averages of 84, 80.7 and 83, and standard deviation values of 8, 11.1, and 6.7, respectively. Also, students from sections “A1,” “B1,” and “C1” who did not perform well in their video scores had lower performances in their overall grades with averages of 67, 78, and 73.4, and standard deviations of 21, 11.8, and 14.51, respectively. Finally, students from sections “A,” “B,” and “C” with average performances of 70, 76’ and 79 in their final grades had larger grade dispersions (standard deviations) of 15, 17.4, and 8.5, respectively, compared to sections “A1,” “B1,” and “C1,” having higher video grades.

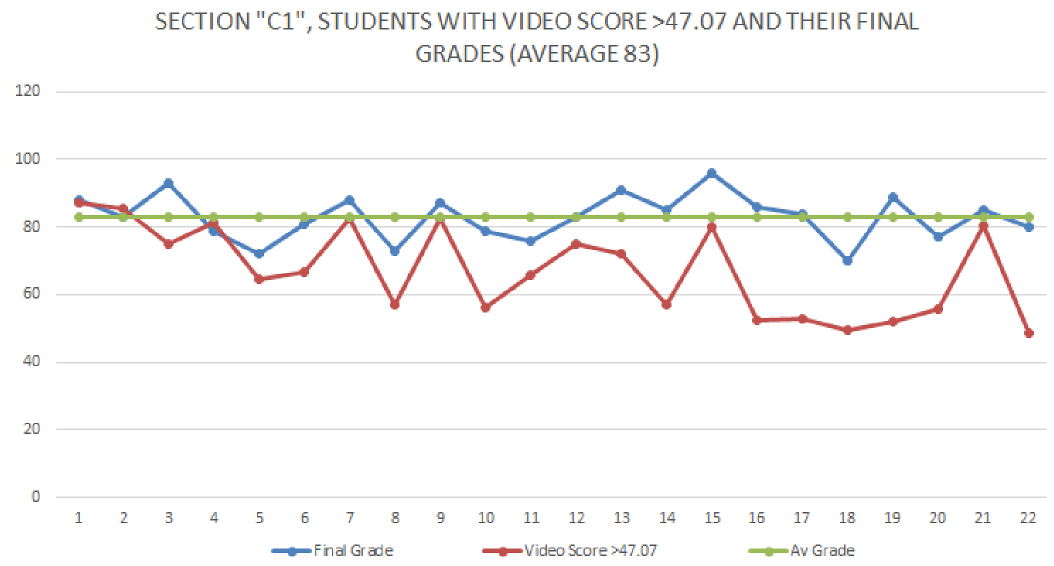

Figure 11: Final overall grades for students from section "C1," who obtained high video scores (>47.07).

The fact that students using interactive videos got good grades in the course could mean that they are very responsible individuals; this may not imply that watching the videos helped them perform much better, necessarily. However, even if the results from sections "A1," "B1," and "C1" are shy, the combination of student engagement and a "little" positive influence of watching videos on grades makes this technological tool valuable in connecting the students to the course contents. Therefore, an exit survey was prepared to find the indication of student engagement in the course as follows:

"In your opinion about the engagement to the course using the interactive videos:

A. Your MOTIVATION to learn the topics improved.
B. Your UNDERSTANDING of some key topics improved.
C. You would like to see MORE VIDEOS in the course.
D. The VIDEOS stimulated your interest in the class topics."

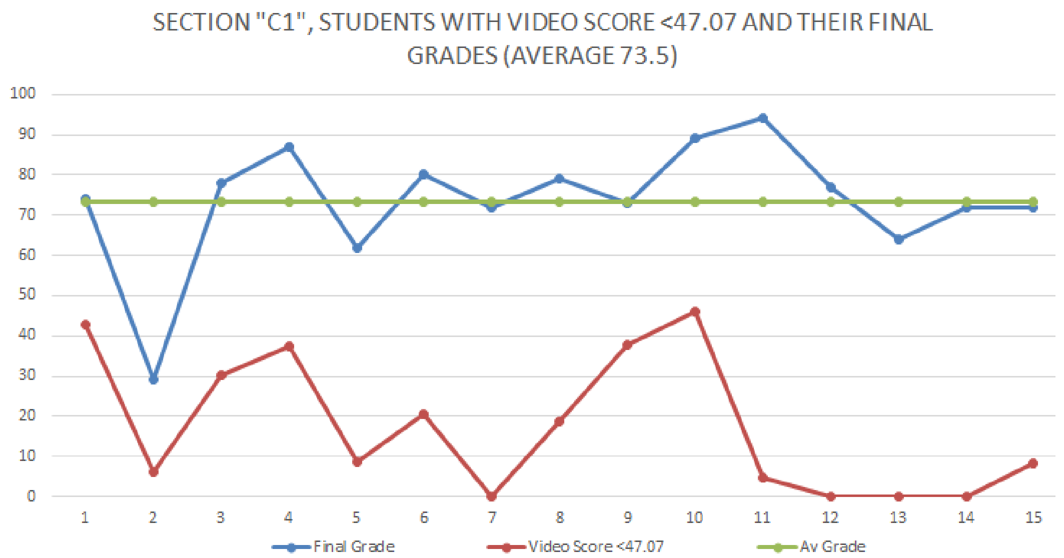

Figure 12: Final overall grades for students from section “C1,” who obtained low video scores (<47.07).

Table V. Comparison Group II: controlled sections A, B, C, A1, B1, and C1

Section	Number of students	Video scores	Interactive Videos available	Average Final Grades	Standard Deviation
A	17	NA	No	70	15
B	17	NA	No	76	17.4
C	27	NA	No	79	8.5
A1	9	>52	Yes	84	8
A1	7	<52	Yes	67	21
B1	23	>76.	Yes	80.7	8.5
B1	11	<76.	Yes	78.6	11.8
C1	22	>47.	Yes	83	6.7
C1	15	<47.	Yes	73.5	14.51

Figure 13 shows the answers given by the students in sections “A1” (16 students), “B1” (34 students), and “C1” (37 students). The results were dominant towards Motivation and Understanding (90.4%). Also, 91.6% took advantage of the videos to understand key topics; 83.1 % of students would like to see more videos on other topics, and 77.1% of students were stimulated about the topics shown in videos.

From additional comments expressed by students in the exit survey, the following ideas summarize the most representative recommendations to improve the interactive video application in this course:

a. The students want to have more circuitry problems and additional examples in the interactive videos.
b. The students would like to see more solved and proposed examples in the videos.
c. The students want to have more videos about other topics.
d. The students want interactive videos with improved audio recording.

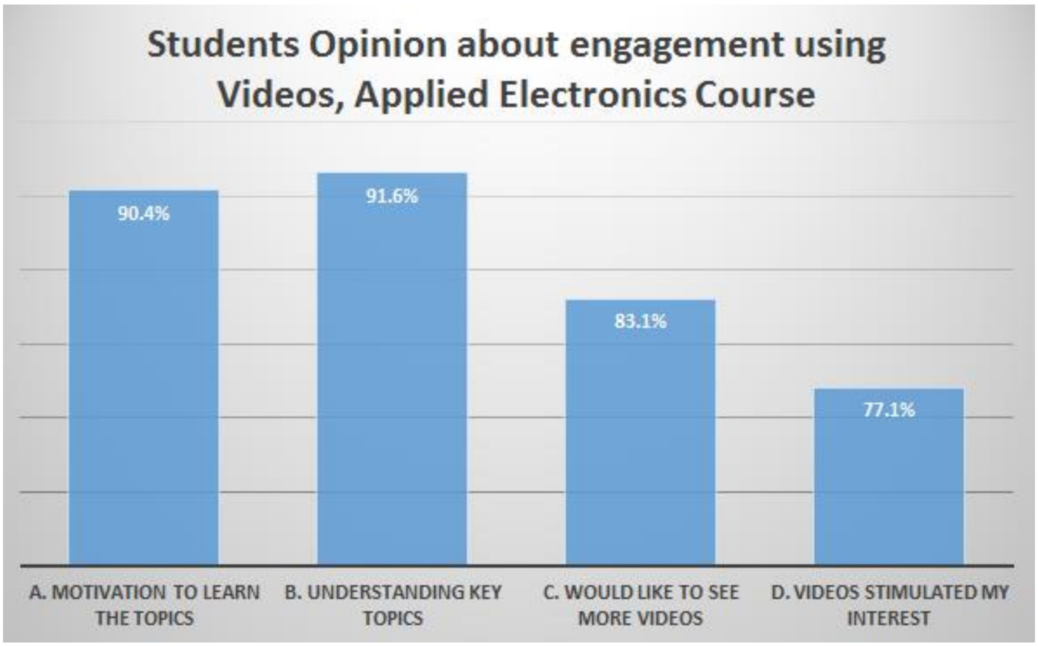

Figure 13: Exit survey results for students from sections A1, B1, and C1.

In the spring of 2018, a new group for video implementation was studied according to the track plan for new degree programs TEC-21. The section “D” involved a large group of students who took Applied Electronics. The number of students was 30, and the number of videos used was 13, as in previous semesters. This section was called D because we were already in a continuous plan of using the videos in the Applied Electronics courses as a normal supplemental resource to the theoretical class lectures. Also, quick simulation experiments were included in order to stimulate student interest in specific design circuits and the experimental development of particular integrated circuit devices. The results were also indicative of some additional advances and help to students during the semester. Figure 14 shows the results for the video grades and the final grades for the 30 students in the class. This graph by itself does not show particular correlations that infer the specific effects of videos just from this graph. Figure 15 shows some of the results for section D (spring 2018) where the final overall grades of students who obtained higher video grades (>73.1, which was the mean value of video scores) in the interactive videos are illustrated. Also, Figure 16 shows the final grades for students who obtained lower video grades (<73.1) for their interactive video performances.

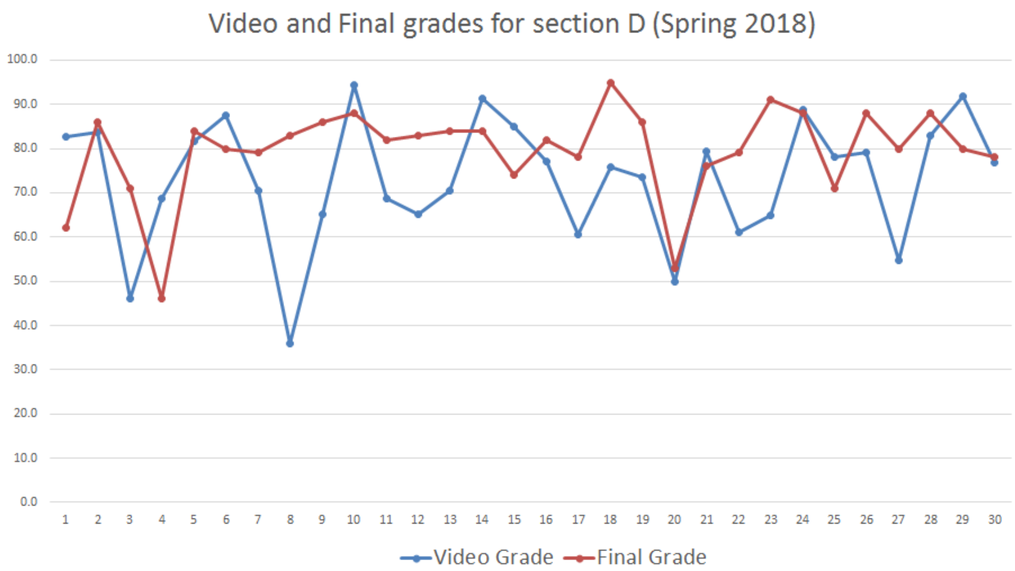

Figure 14: Video and final grades for section D, having 30 students in Fall 2018.

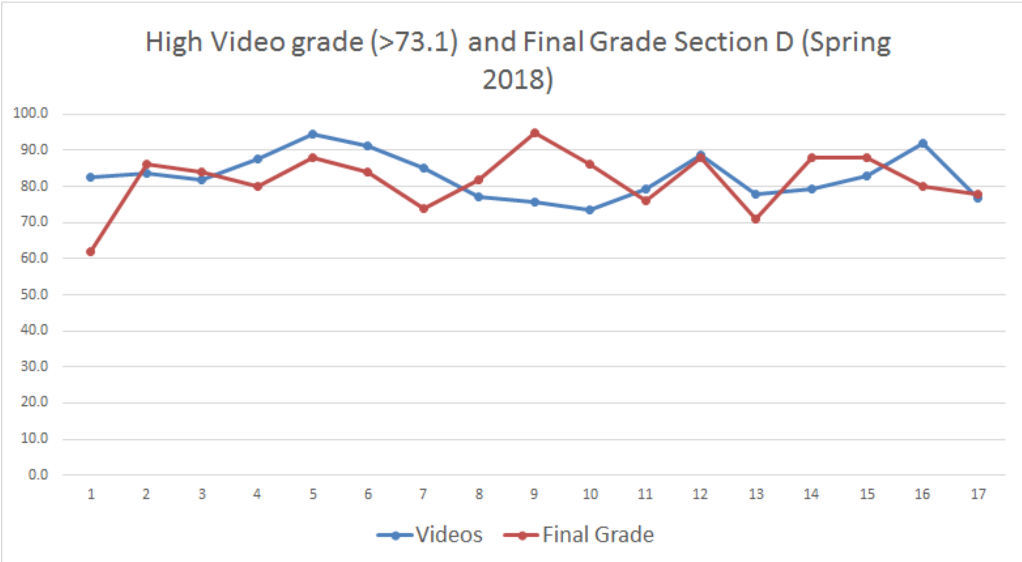

Figure 15: High video grades and Final grades for section D, having 30 students in Fall 2018.

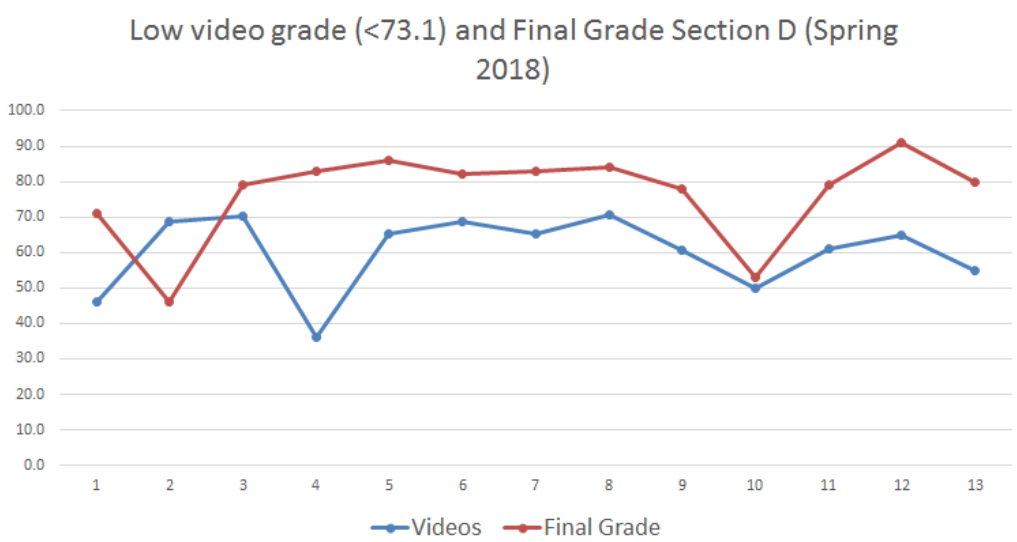

Figure 16: Low video grades and Final grades for section D, having 30 students in Fall 2018.

Group III results from Figures 2, 3, 4, 13, 14 and 15 can be summarized in Table VI. Table VI shows that students from section “D,” who performed relatively well in their video scores (having scores above the class average of 73), had a much better performance in their overall grade with an average of 81.8 and a standard deviation value of 7.9. Also, students from section “D” who did not perform well in their video scores (having scores below the class average of 73) had lower performances in their overall grade with an average of 76.5 and a standard deviation of 12.95. Finally, students from sections “A,” “B,” and “C” with average performances of 70, 76 and 79, respectively, in their final grades obtained larger grade dispersions (standard deviations) of 15, 17.4, and 8.5, respectively, compared to students of section “D” having higher video grades. In this case, the standard deviation was 7.9.

Table VI: Comparison Group III: controlled sections A, B, C, and D (30 students in the group)

Section	Number of students	Video scores	Interactive Videos available	Average Final Grades	Standard Deviation
A	17	NA	No	70	15
B	17	NA	No	76	17.4
C	27	NA	No	79	8.5
D	17	>73	Yes	81.8	7.9
D	13	<73	Yes	76.5	12.95

Results and Exit Surveys of the i-week project EFR

Table VII illustrates the students’ opinions with respect to workshop content, instruction by SSNL, consulting and instruction by TEC faculty, time allocation to different topics, and supporting materials such as audiovisuals and tools. With regard to the overall opinions and recommendations of the activity by the students, they suggested some precise actions to improve, even more, the experience in terms of management, logistics, organization, and structure. Improvements were performed for the EFR-2016, EFR-2017, and EFR-2018 editions of the project.

The students also provided their opinions with respect to recommending the activity for future semesters at Tecnologico de Monterrey. Table VIII shows opinions from 182 students attending the workshops from 2015 to 2018.

Table VII. How did students like the fundamental elements of the EFR?

How did students like…?	**% of students saying: EXCELLENT**	**% of students saying: VERY GOOD**
Workshop content	59	33
Instruction by SSNL	61	28
Consulting/instruction by TEC faculty	73	22
Time allocation	39	33

Supporting materials including the interactive VIDEOS	62	37

Table VIII. Student Expectations and Recommendations to others in EFR.

Were your expectations fulfilled?	**Would you recommend the workshop?**
YES	YES
88%	92%
Opinions of 182 students taking an exit survey at the end of the workshop	

When the students delivered their products, personnel from SSNL and CENAPRA were part of the jury in the final oral presentations. Figure 17 illustrates the typical categories of the different product prototypes developed by the students during the 2015, 2016, 2017, and 2018 editions of the EFR i-week. SSNL and CENAPRA were very optimistic about the use of the generated products and applications. The multidisciplinary and collaborative [27, 34, 35, 36, 37] approach to the EFR project was so successful that a continuing project is being developed for the CS faculty to provide a follow up to the best applications, prototypes, and proposals.

Finally, the Tecnologico de Monterrey applied an institutional survey to a sample set of students participating in the i-Week [38]. For instance, in 2015, opinions from 3,966 students from the Monterrey campus (C.MTY) were collected, and 64 of them offered comments about the EFR Experience. Figures 18 and 19 summarize student opinions with respect to their living experience and their satisfaction, respectively. Figure 3 shows that more than 50% of the students participating in the Emergency First Response (EFR) activity had a Good to Excellent opinion about the “Living Experience" during the i-Week at the Tecnologico de Monterrey. Figure 4 shows that about 75% of the students participating in the EFR activity had a Satisfied to Very Satisfied opinion about the i-Week Workshop. Finally, considering the overall opinion of the students participating in the EFR experience, Figures 18 and 19 illustrate that the number of students with positive opinions is much higher than the percentage of students from the EITI and C.MTY (Tecnologico de Monterrey, Monterrey campus). Also, the figures show that the number of negative opinions of EFR students is much lower than the number of negative opinions from the EITI and C.MTY.

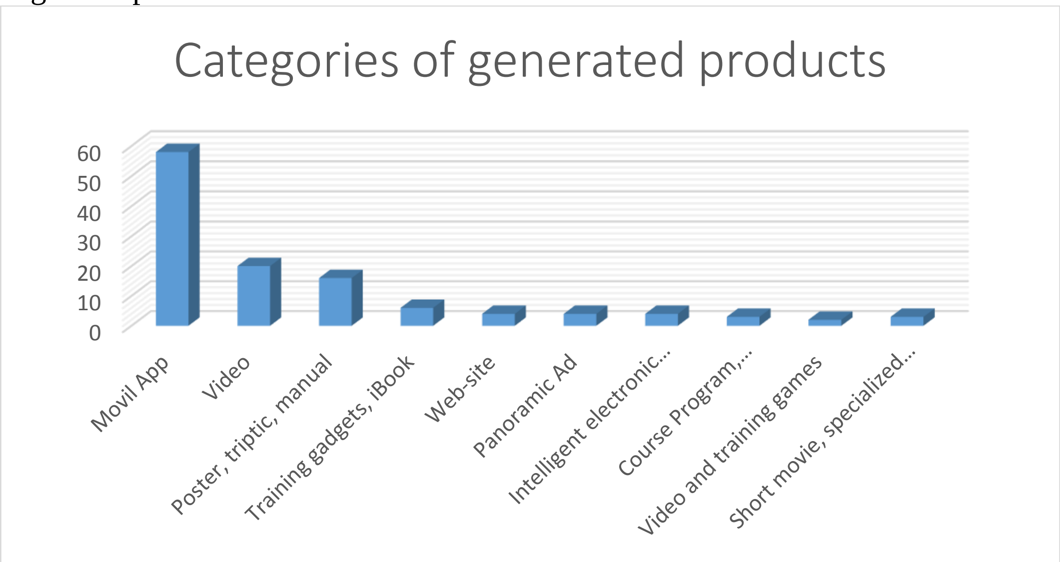

Figure 17. Typical categories of the product prototype generated during the EFR i-Week from 2015 to 2018.

7. Conclusions

We studied the effectiveness of the use of short, interactive videos (less than 15 minutes) in the Applied Electronics class, which included the i-Week activity. The study assessed their impact on the overall course grades as well as students' opinions about their engagement due to having interactive videos as a learning tool. From the controlled section "A1," where the interactive videos were available, 44% of the students recorded less than 52 in their video scores, and their final average course average grade was 67. On the other hand, the other 56% of the students who had higher than 52 in their video scores achieved a final group course average grade of 84. The study also shows a positive impact on students' final grades in another two controlled sections from different semesters. Exit polls indicate that 90.4% of students favored using interactive videos because they provide higher motivation to learn the class material. Also, 91.6% of students believed that the videos helped them understand key topics, and 83.1% of the students want to see more interactive videos in class. The total number of students exposed to videos was 124; they were in 4 sections ("A1," "B1," "C1," and "D") from the spring of 2016 through spring 2018. The interactive video strategy continues in 2019 and beyond with the inclusion of larger sample groups and other academic departments such as computer science, information technologies, physics, and mechatronics. With respect to the i-Week project, embedded during the fall semester sessions, the EFR project has used 10 different videos to train 764 students as first responders in Northeast Mexico from 2015 through 2018. They are now prepared to provide medical attention to individuals having accidents or sudden cardiovascular illnesses. In addition, 35 professors from areas such as Computer Science, Electrical Engineering, and Information Systems and another 24 collaborators have also been certified to provide this kind of service not only on the Monterrey campus but also abroad. The videos help to provide the initial methodology that will expand to achieve higher benefits in the academic community.

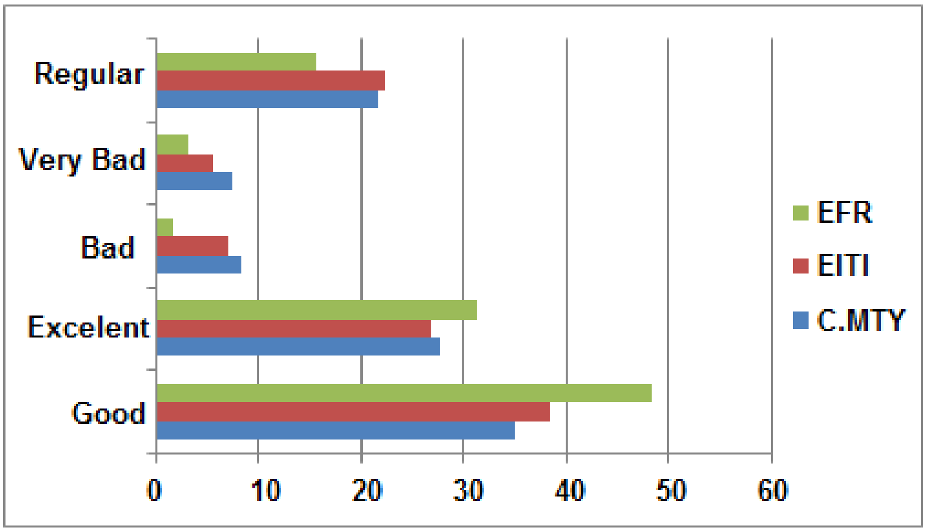

Figure 18. Institutional survey to students (Tecnologico de Monterrey, 2015). Question: "How was the living experience at the i-Week?"

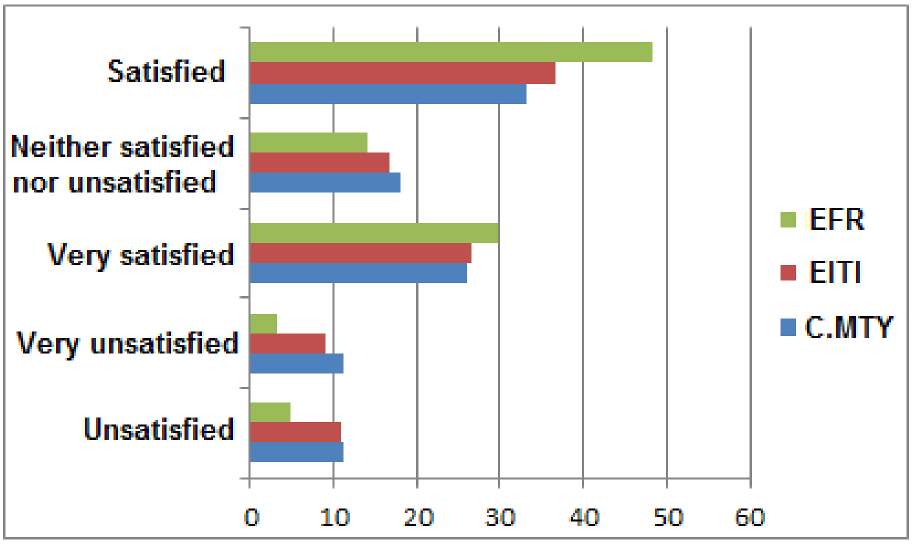

Figure 19. Institutional survey to students (Tecnologico de Monterrey, 2015). Question: "What was your satisfaction level during the i-Week?"

In the EFR project having the supplementary video methodology, the exit surveys show that 88% of the students felt their expectations fulfilled, and 92% would recommend the workshop to future students at TEC. The replication of this project at TEC enhances the development of technologies and applications by students working not only in areas of science and engineering but also in most of the university undergraduate programs. The EFR and the videos used have been improved since 2015 to provide an even higher and more enriched environment for innovation and project development. The interactive video technology is a very important complementary methodology in the Tec21 new degree programs [14] that started in the Fall of 2019 at the Tecnologico de Monterrey.

Acknowledgments

The authors would like to acknowledge the financial and technical support of Writing Lab, TecLabs, Tecnologico de Monterrey, in the production of this work. In addition, the authors would like to acknowledge the support of the Mechatronics, Electrical and Biomedical Engineering department for their support in developing the tests, programming the sessions, and performing the pilot testing of this study. Moreover, during the 5 years of implementation of "*Emergency First Response Project*", we would like to acknowledge the following participating professors: María Guadalupe Piña, Hugo Alvarado, Dolores Lankenau, Bertha L. García de La Paz, Alejandro Cervantes Villarreal, Antonio Mejorado Cavazos, María Marcela Dieck Assad, Martha Sordia Salinas, Javier Rodríguez Bailey, María Elena Dieck Assad, Josefina Rangel Sánchez, Delia Castro, Heidi Alejandra Rosas Treviño, Francisco Rodríguez Abrego, Dorilián López Mago, Miguel Angel Pérez, José Julio León, Jaime Martínez Garza, Juan Raúl Esparza, Alejandra González Avila, Rafael Salazar Chávez, Ivón Rodríguez, Juan Carlos Lavariega Jarquín, Alfonso Avila Ortega, Jakeline Marcos Abed and Sergio Omar Martínez Chapa. In addition, a great acknowledge must go to personnel from the Mexican Health Ministry, Nuevo León State Jurisdiction 3: Maria Gloria Chavez and Luis Ernesto Rodríguez.

References

[1] Morris C., Chikwa G. (2014), Screencasts: How Effective Are They And How Do Students Engage With Them, Active *Learning in Higher Education*, 15(1), 25-37, UK.

[2] Mullamphy R.E., Higgins P.J., Belward S.R., et al. (2010), Screencast or Not Screencast, ANZIAM Journal, 51: C446-60.

[3] Pinder-Grover T., Millunchick J. M., Bierwert B., (2008) Work in Progress - Using Screencasts to Enhance Student Learning in a Large Lecture Material Science and Eng Course, 38th ASEE/IEEE Frontiers in Education Conference, October 22-25, Saratoga Springs, N.Y.

[4] Guedes D., Almeida P., (2009), Integrating Podcasts, Vodcasts, Screencasts, and Emerging Casting Technologies in the Teaching/Learning Context Higher Education, 5th Iberian Conference on Information Systems and Technologies, June 16-19, 1-7.

[5] Mohorovičić, S. (2012), Creation and Use of Screencasts in Higher Education, *IEEE MIPRO Conference*, May 21-25, Opatija, Croatia.

[6] Pedrotti, M., Nistor N. (2014), Online Lecture Videos in Higher Education Acceptance and Motivation Effects on Students' System Use, *IEEE 14th Int Conf on Advanced Learning Technologies*, 477-479.

[7] Kolås L., (2015) Application of interactive videos in education, *IEEE Int Conf on Information Technology Based Higher Education and Training* , June 11-13.

[8] Kerr, B., (2015), The flipped classroom in engineering education: A survey of the research, *Proc of Int Conf on Interactive Collaborative Learning*, 20-24 September, Florence, Italy.

[9] EDpuzzle Inc., (2019) *EDpuzzle Technology*, Class Twist, Inc., 735 Tehama St, San Francisco, Ca, 94103, https://edpuzzle.com .

[10] Serrano A., Ponce R., Rodríguez G. and Rincón E. (2015), Videos Interactivos Implementados en Modelos Educativos, *in Proceedings of the II Int Congress of Innovation in Education at the Tecnologico de Monterrey*. On line: http://ciie.itesm.mx/es/sesiones-paralelas-10/

[11] Screencast-O-Matic, (2019), *Software to record videos using your PC*, 600 Stewart Street, Suite 400, Seattle, WA 98101, http://screencast-o-matic.com/home .

[12] Alvarado I., (2017), Global Impact of ECE in Society, *ECEDHA Annual Conf & Expo*, March 17-21, Miramar Beach, Florida. http://www.ecedha.org/conferences/2017-ecedha-annual-conference-and-ecexpo/2017-schedule/global-impact-of-ece-in-society

[13] Camtasia, (2019), *Camtasia software for video recording*, TechSmith Corporation, 2405 Woodlake Drive, Okemos, Michigan 48864-5910, https://www.techsmith.com/camtasia.html.

[14] Tecnologico de Monterrey (2019) *Electronics Eng Challenge Based Degree Plan 2019*, Available at http://admision.itesm.mx/es/ingenieria-innovacion/ie .

[15] Lancaster J.W., Wong A. and Roberts S.J., (2012), Tech´ versus ´Talk´: A comparative study of two different lecture styles within a Master of Science nurse practitioner course, *Nurse Education Today* 32(5): 14-8.

[16] Petty J. (2013), Interactive, technology-enhanced self-regulated learning tools in healthcare education: A literature review, *Nurse Education Today* 33(1): 53-9.

[17] Ford M.B., Burns C.E., Mich N., et al. (2012), The effectiveness of classroom capture technology, *Active Learning in Higher Education*, 13(3): 191-201.

[18] McGarr O. (2009), A review of podcasting in higher education: Its influence on the traditional lecture, *Australasian J of Educational Technology*. 25(3): 309-21.

[19] Anisimova T.I. and Krasnova L.A., (2015), Interactive Technologies in Electronic Educational Resources, *Int Education Studies*, 8(2), 186-194.

[20] Lai C., Wang Q., and Lei J. (2012), *What factors predict undergraduate students´ use of technology for learning? A case from Hong Kong*" Computers and Education 59(2): 569-79.

[21] Dieck-Assad G. et al. (2015, 2016, 2017, 2018) EITI and EIC, Emergency First Response, Instructor´s Kit, Semana-i. EGADE-EGTP Tecnologico de Monterrey, September 2015, 2016, 2017, and 2018. Dieck-Assad G. (2015, 2016, 2017, 2018) *Minutes of the EFR instructor´s meetings* for January 23, February 6 and 27, March 20, April 10 and 24, August 7, 14, and 28, September 4, 11, 18 and October 2, 2015. January 15, March 9 and 30, April 20, May 25, June 29, August 12 and 31, September 7 and 14, 2016. March 15, April 26 and 28, May 24, August 24 and 25, September 14 and 15, 2017, November 24, 2017. April 6, April 20, June 8, August 8, August 31, 2018. Dieck-Assad G. et al. (2016), *Innovation Week (i-Week), a Way to Link Students, Industry, Government and Universities; the case of Emergency First Response at the Tecnologico de Monterrey* , III Congreso Internacional de Innovación Educativa, CIIE-2016, México City diciembre 14-16, pp 2644-2657. Dieck-Assad G. (2018), *Emergency First Response 2015-2018; Proyecto Desarrollado durante la semana-i en EGADE-EGTP-TEC, Sep. 2015, 2016, 2017 y 2018,* Presentación ante COEPRA, octubre 18, 2018.

[22] Secretaría de Salud México (2016) Manual para la Formación de Primeros Respondientes en Primeros Auxilios, Centro Nacional Para la Prevención de Accidentes CENAPRA. Available at: www.cenapra.salud.gob.mx, (accessed May 11 2015). Secretaría de Salud Estado de Nuevo León (2015, 2016, 2017) Presentación para capacitación de primeros respondientes. Also Coordinación de Secretaría de Salud y Desarrollo Social del municipio de San Pedro. Available at http://www.sanpedro.gob.mx/primerrespondiente/res_index.asp , (accessed May 18, 2015).
[23] Buscell P. (2015) Spontaneous Self-Organization in Disasters, The Plexus Institute web Page: http://www.plexusinstitute.org/ , (accessed on July 10, 2015).
[24] Nair P. (2008) 30 Strategies for Education Innovation, Designshare.com, accessed Nov. 12 2015).
[25] Khan S. (2007) The One World School House, in Twelve, pages 76-80.
[26] Hefferman V. (2011) Education Needs a Digital-Age Upgrade. The New York Times, Aug. 7, 2011.
[27] Oppenheimer A. (2015) *Create or Die, The hope for Latin-American and the five key factors for Innovation*, Debate Publishing Co, 300-330. Oppenheimer A. (2014) Salman Khan and flipped Schools in *Create or Die*, Random House, pp. 216-244.
[28] Webb J., (2015) GeoVisible, Help is on the way! Join Our Team, Help Save Lives, National Emplea-TEC 2015, Tecnologico de Monterrey, Monterrey México, (accessed Oct. 8-9, 2015).
[29] Ambu Res-Cue Mask (2009) Baltrobakken 13 DK 2750, Ballerup Denmark. Available at www.ambu.com.
[30] Jansson P., Ramachandran R., Schmalzel J., Mandayam S. (2010) Creating an Agile ECE Learning Environment through Engineering Clinics, *IEEE Trans on Eng Education*, 53(3): 455-462.
[31] Tafa Z., Rakocevic G., Mihailovic D., Milutinovic V. (2011) Effects of Interdisciplinary Education on Technology-Driven Application Design. *IEEE Trans on Education*, 54(3): 462-470.
[32] Plaza I., Igual R., Medrano C., Angeles Rubio M. (2013) From Companies to Universities: Application of R&D&I Concepts in Higher Education Teaching. *IEEE Trans on Education* [serial online]. 56 (3): 308-315.
[33] Díaz L.J. and Garza G. (2018) “Medical Emergency Training in Schools, Clubs, and Social Organizations,” Organizational Meeting and Planning, (August 7, 2018).
[34] Florida R., (2015) *The Flight of the Creative Class: The New Global Competition for Talent*, Harper Business, New York, 5-30.
[35] Benyus J.J., (2002) *Biomimicry; Innovation Inspired by Nature*, Perenial HarperCollins Publishers Inc. New York, 1-10.
[36] Casado F., and Hart S.L. (2015) *Base of the Pyramid 3.0: Sustainable Development through Innovation and Entrepreneurship*, Greenleaf Publishing Ltd, UK, 11-30.
[37] Govindrajan V. and Trimble Ch. (2012) *Reverse Innovation*, Harvard Business School Publication, Boston, Massachusetts, 20-35.
[38] Tecnologico de Monterrey (2015) Resultados de la Semana-I a Nivel Actividad ("Results of I-Week at Activity Level"), Tablas Actividades Semana-I, November 5, 2015