

E-LEARNING DURING COVID 19 PERIOD: FLIPPING THE CLASSROOM AND GAMIFICATION AS LEARNING METHODS FOR MATHEMATICAL UNDERSTANDING IN ARCHITECTURE.

Santa Ana Lozada PR

Tecnológico de Monterrey Architecture, Art and Design School, Mexico

Abstract: Coronavirus change the world included teaching approaches. With schools closed, technology has become a powerful tool for educational purposes; the potential of e-learning affects education significantly as it provides improved informational content and interactive apps to apply theoretical knowledge. Teaching methods should be considered for each subject to ensure students get significant experience. This paper summarizes findings from an empirical study involving a new integrated e-learning method for the architecture structural design course using flipping the classroom and gamification as learning methods. The e-learning solutions used were short videos containing each subject's essential theory and interactive software programmed as smartphone applications containing the course subjects. A web site with the class videos embedded and examples for solving the application's games ensures students get the same information and practice the same exercises. A comparison between classes on-site and online classes is presented to assess this new method's effects. Results were promising; students like to learn about the class subjects at their own pace; they enjoyed practicing mathematical and physics theory feeling inside a video game mood. Students gained motivation, engagement, and good grades during this online learning period; no final exam was needed as they presented a final project using the structural concepts learned.

Keywords: educational innovation, flipped classroom, e-learning, gamification

Introduction

E-learning, according to Naidu (2006), refers to an educational process that uses networked information and communications technology in teaching; it would incorporate all educational activities carried out online or offline, synchronously, and asynchronously via networked or standalone computers and other electronic devices. The four E-learning modalities are Individual self-paced online, individual self-paced offline, group-based synchronously, and group-based asynchronously. The growth of e-learning is related to the increasing access to information and communications technology, so contemporary students (millennials, Gen Next, and forward) have grown up using these technologies and expect to see them being used in their educational experience (Brown, 1989).

Before 2020, the e-learning environment's use changed the traditional learning system using constructivist principles of learning (Magnussen, 2008), allowing students to construct their

knowledge, providing students with skills that enhance understanding while learning the modalities e-learning offers. E-Learning most common forms are applications, programs, objects, websites that can provide a learning opportunity for individuals (Moore *et al.*, 2011). Pedagogical design that stands to optimize e-learning includes scenario-based learning, problem-based learning, case-based learning, role-play-based learning, etc.

As the COVID-19 pandemic spread and schools were closed, students and teachers shifted to online learning. This situation gave an excellent opportunity to turn to e-learning technologies, with its appropriate learning strategy to create an active learning course in which students are fully engaged in discovering the subject, resulting in more excellent retention, understanding, and joy to learn.

A new integrated e-learning method was created based on a previous author's learning method; this last method was based on a gamification strategy and a smartphone app programmed with the class topics. It was created before COVID-19, demonstrating successful results (Santa Ana, 2020).

Considering that students are getting tired of being online every day due to the Post COVID-19 effect, many professors proposed classes should be practical and short. For this purpose, video lectures and a website were developed, and flipping the classroom strategy was included to create this new e-learning model.

Research objectives

The scope of this research is to present the new method designed for online classes during the post-Covid-19 times and the impact measurement of this method improving students' class subject understanding; for this research, the subject's topic is an architecture-structural design process. This method facilitates the learning of abstract mathematical and physical concepts related to structural design for architectural students.

This new e-learning model was implemented a year ago in the School of Architecture at Tecnológico de Monterrey, Campus Ciudad de México within the courses named Tense-structures design and Steel structures design. With two semesters being applied this method, it has shown remarkable results, especially during the COVID-19 period with online classes. Benefits found using this method were students engaged with the subject, relief without the time pressure getting integration of the theory to the practice, and practicing at their own pace the skills needed for solving architectural-structural problems

The work done for the research is based on a specific successful education experience, but the method described can be adapted to any other context or subject.

The new method's learning strategies and their e-learning tools

Fink (2003) proposed that constructive courses should promote learning that comes from understanding, identifying six necessary components to create significant learning, also called taxonomy; these components are: a) foundational knowledge; b) application; c) integration; d) human dimension; e) caring and f) learning how to learn. When planning their courses, teachers should use different combinations of e-Learning forms and learning strategies using Fink's taxonomy to provide a more significant learning opportunity for students.

Skillful integration of information and communications media and instructional methods (i.e., learning strategies) is critical in optimizing media influence in learning. (Naidu, 2006). A careful selection and matching of media attributes with learning and teaching strategies should be made to get a learner and learning-centered educational process. Situated learning is grounded in the principles of constructivist learning theory (Wilson, 1996).

Before creating the integrated e-learning method, the learning strategies selected are explained with the correspondent e-learning tools. The selection of the learning strategies depends on the class's topic, considering Fink's taxonomy.

Huang et al. (2018), presented the results of a study that examined whether gamification enhanced students engagement in a flipped course, and their conclusions were very positive indicating that students produced higher quality products and scored higher in post-course test. This study supported our method of joining different learning strategies to get better results in class.

Gamification

Gamification is the use of game thinking, approaches, and elements in activities that are not games, improving motivation and learning in formal and informal conditions. Its distinctive features are students become users or gamers to solve challenges to accumulate points and get levels or ranking according to their achievements, receiving badges as a reward. An effective gamification strategy should consider students' background and their predisposition to participate. The learning objectives must be specific and clear. The educational content should be interactive and, finally, the inclusion of tasks that should be performed to achieve the learning objectives.

The software or applications used for gamification strategy are essential. The selection of the software or app that covers the class's specific topic depends on the process and results they return the student. For the subject of this research (architecture-structural design), a digital learning app was selected. The application name is APPRENDESTRUCTO, and it was programmed using base-learning scenarios (pedagogical design where one or more learning scenarios serve to anchor and contextualize all learning and teaching activities (Naindu, 2006)) three years ago. It is a free download app with characters, plot, and context that places the student in a role that requires dealing with structural-architectonic problems using mathematical and physic concepts. Students' roles are likely to play in real life as they enter the workforce; to achieve their goal, students are required to perform assigned tasks that serve as enhancement exercises that contribute to the student's final grade in the subject.

Flipped classroom

Flipping the classroom is known by various names, including inverted classroom or the flip. It has two defining components: moving the lecture outside of class, usually delivered through some electronic means, and moving the practical application assignments into the classroom. Many other features could optimize this structure, providing countless paths as the learning context and objectives are different. (Arnold-Garza, 2014).

For this new model method, video lectures of the main topics (physics relation with structure design in architecture) were made, breaking the theme into several videos addressing subtopics (chunking), helping students access and process a large, interconnected set of ideas efficiently. Video lectures

have a length of 5 min maximum to avoid losing the student attention; they were programmed using Powtoon free license, inserting friendly characters that move and explain theory simple and straightforward. These video lectures allow students to increase meaningful engagement for students; the time spent in the classroom online is optimized to explore concepts deeply and practice.

To attain the goals, students have access to a website programmed by the author to find relevant multimedia content such as video lectures, reading material with the solution solved step by step or view augmented reality of each building on the app.

New method steps and their application for structural understanding in architecture

Considering the method created previously for structural understanding in architecture based on gamification (Santa Ana, 2020), based on the six steps method by Hsin *et al.* (2013), and analyzing the advantages and disadvantages of the online classes during this Covid19 era, the steps for this method integrating flipped classroom are:

A. Defining learning objectives

What is the primary purpose of the course? What learning strategies could be applied for the course or for each topic to achieve the primary objective? It is essential to balance learning strategies in a class; if the same methods are used along the course, students may get bored, but applying too many techniques may lose the students' attention and the courses' purpose.

The primary purpose of the new method for structural understanding in architecture is to explain the physical behavior of the structural elements (beams, columns, etc.) and their application to architectural solutions.

B. Structuring the experience and identifying resources

Teachers should review the class syllabus, identify the topics, and select the software, application, or video lectures that best fit to get the course's primary purpose according to the learning strategy chosen is vital.

For structural understanding in architecture, topics included in the phone app with their video lecture are selected for flipped classroom and gamification strategies; not every topic of the course is included in the game app or has a video lecture. For this research, around 70% of the topics used the new method; the remaining issues are taught using a problem-based learning method, but all subjects must be related no matter the learning strategy.

C. Applying flipped classroom and gamification elements

Problem-solving activities that confront learners with authentic situations and scenarios motivating and require learners to carry out solving problems and reflect upon their actions (Naidu, 2005) are related to the selected learning strategies.

For students to be successful in this learning environment, they must have the ability to be organized, evaluate and monitor their learning progress. Because not all students possess these skills, a specific

method is made with clear instructions and clarifies the goals students must follow to apply the method correctly.

For the method proposed, exact instructions are placed over an educational platform (Canvas, Blackboard, Classroom, etc.) with the tasks they must do described step by step to get better results: a) to attain the goals, students should access to a web site programmed by the author where they can find relevant multimedia content (.i.e video lectures, problem solutions solved step by step); b) The name of the video lecture for the specific topics are stated; c) The location of videos illustrating how the app works are specified; d) the application location is demonstrated so students can download it; e) they start using the app; when the students are confident they start playing and winning points that can be used as extra points for the course final grade.

This page's format is essential to get a good gamification response; the gamer mood was created to engage the student's interest and immerse him in this game environment. Video game pictures were attached, and all students are treated as gamers in a training program. Students have reported that reading the instructions and knowing how points are gained introduces them to a video game mood, which motivates them.

Meanwhile, in online classes, the theory is reviewed, and exercises with these topics are solved. Time is assigned to solve students' theory/solution doubts or any problem they could find while playing the game.

D. Moderating online learning

Moderation refers to the acts of managing, facilitating, and engendering group-based computer-mediated communications. When the teacher is not with the student during the learning process, moderation takes a vital degree.

For this method, communication with students is synchronous in communicating during class by zoom and asynchronous using course discussion forums with canvas, blackboard, or classroom. For asynchronous cases, students post messages about doubts, problems winning each app, and the professor must answer each message as soon as possible.

E. Recap

Every group has different needs or times for each topic and strategy. Timing, app selection, length for each subject, etc., every feature should be considered to get better results.

For the method proposed, many changes have been made during these two years. Working with different groups and subjects have given a better timing for each video material, the length each learning strategy should have, and how to relate all topics at the end of the course. It is a never-ending process.

The learning experience in the classroom

This new method was applied to different groups: Tensile-structures and Steel design courses for the last two semesters. These courses' main topic is material mechanics applied to steel elements'

structural design through theoretical explanation and practical solutions. Classes are held twice a week and follow the new method exposed.

As stated before, 70% of the topics incorporate flipped classroom and gamification, while the 30% remaining apply PBL. Every week of the course is programmed since the first day, so students can recognize the topics and the steps they must follow according to the respective learning strategy. Before Covid-19, students make teamwork must of the time; now, in Covid-19 times, students work alone playing the app and watching the video lectures; they collaborate while working with PBL.

Students are instructed to start each topic with a video-lecture. After that, they read the abstract of the physical theory for each subject and then start playing the app that contained two or three problems; the learning complexity increase with each exercise. When the student finished all the app tasks (quests), they get game points that could be exchanged for additional monthly grade points. After the quest is completed, students bring their conclusions and share them to solve the last topic problem working with PBL strategy.

The learning scenario, flipping the classroom and gamification with the assessment tasks, serves as essential scaffolds for promoting and engaging in meaningful learning activities. It also motivates learners to focus on the subject matter content and its practical skills.

Assessment results of the new method

A comparison study was conducted, involving three classes of undergraduate students taking the same course at different times using different learning strategies. These experimental groups had around 20 to 25 students each semester. The last group took classes on line during the lockdown Covid19 pandemic.

The method of assessment for the subject is criterion-referenced, in which the student requires to demonstrate the presence of learned capabilities concerning the physics subject and its architecture-structure application. Students must solve a real structure design problem using the physics topics learned while watching the theory, playing the app, and the experience of an exercise solved during class. To improve learning outcomes, students make their portfolios where all their e-learning activities and learning strategies are kept.

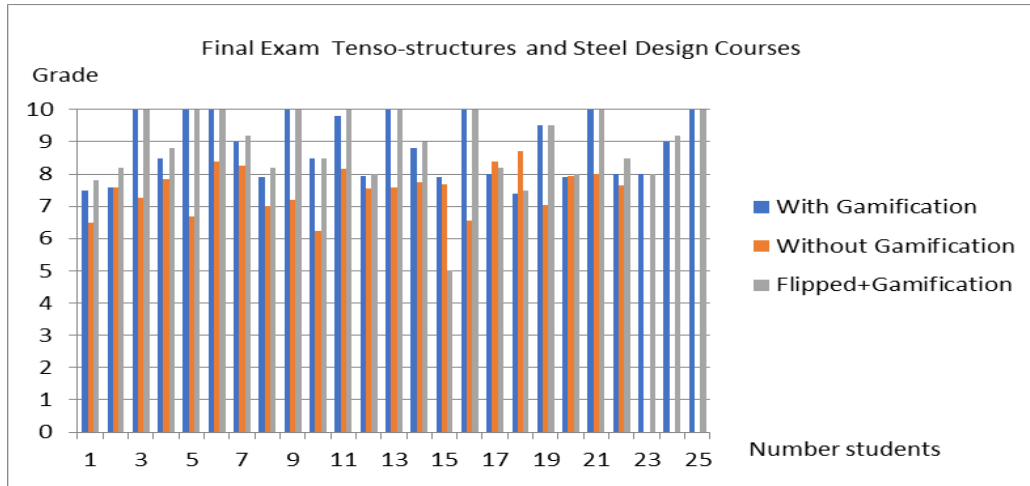


Figure 1: Comparison of final exam grades between courses

Students' performance improved by applying this new method from the previous method, which uses gamification. We compared the final grades of two group post-Covid 19 workings online all the course, as shown in figure 1. In this last figure, red lines correspond to students that took these courses before Covid-19 using only PBL strategy; blue lines are the grades of students that took the same course but with gamification method (before Covid-19); green lines are grades of students with course online post Covid-19 using the new method (flipped+gamification+PBL). Students enjoy the class as they learned and spent fewer hours in front of the computer screen; a considerable improvement in grades can be found. Most importantly, students feel more relaxed learning as they reported over the course evaluation.

Students Feedback regarding the new method

Students' satisfaction was evaluated with the application of this new method. The scores were based on the Likert scale in five-point grade, five being the best score. It can be seen in Table I that students' experience was positive; students felt free without being in front of the computer screen, they were motivated and considered attractive the fact of having video lectures and using the application to learn the topics.

Table 1: Evaluation of students of the method performance.

Phrases	Evaluation
Instructions in Canvas helped to get all tasks done	5
The app helps to understand structural behavior	4
Playing the app at your own paced was enjoyed	5
Video lectures and app clarifies the theory applied to real cases	5
Performance of the course	4

Considering other studies about gamification with flipped course strategy, the results of this study sustain the benefits students get using both learning strategy: improvement in their behavioral and

cognitive engagement (Huang et al, 2018). Moreover, students using Problem based learning with flipped classroom and gamification scored significantly higher than students in prior courses without this new method.

Conclusions

For this research, the method proposed for the architecture-structure design subject uses visual tools that are quite important to integrate theory with practice and get foundational knowledge. The primary e-learning forms needed for this method are phone applications interacting with gamification learning strategy and video lectures on a website to flipping the classroom.

Adding flipping the classroom helped students to learn at their own pace, without being in front of a computer screen all day in classes. Networked information and communications technologies enable the storage of educational resources and allowing students to access this content (video lectures or app instructions) at any time.

Using gamification as a strategy helps students better understand but forget the stressful situation about Covid-19 confinement. At the same time, they enter a virtual environment to solve real-world challenges without hurting anyone if they fail their task.

Fortunately, the author had created all the material needed for the method: i) Video lectures with the specific theory and examples of cases solved, controlling its length and information; ii) Web site using the same pictures that the app uses and giving a particular order to engage students and making easy to find things they need; iii) creating the application with the topics and different problem solutions according to the class topics and theory. Creating all the material gives more control to reach the course's final objective, especially when it is not easy to find Spanish learning material about this topic and its application in architecture. But this would not be the case for every teacher.

The difficulties that may be found by teachers that would like to use this method for their courses are a) finding the right software or applications that fit the topic and subject objective; many times should be invested by teachers, who must play the apps to evaluate it there is a link between the app results and the learning purpose; b) the software or applications should exist for all operating systems (i.e., IOS, Android, Windows); c) the gamification strategy must be adapted each time, considering the length, number of topics, number of exams, etc. that the course has; d) Video lectures should be short and effective in the way it communicates the theory to the students; for this method, video lectures were created using Pow Toon with sound to engage students attention.

After each semester ends, modifications to this method are detected to improve it. It is an endless job to find the best way to create significant learning for this new era of students. It can still be done with the strategies proposed: flipped, gamification, and PBL, or many others, depending on the resources and final learning objective.

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