Review of the multi-strategic effective online teaching model for undergraduate students in computer sciences courses

Diana López Robledo
Departamento de Administración de Empresas y Ciencias en Computadoras
Universidad de Puerto Rico en Ponce

Resumen

Las instituciones que ofrecen cursos en línea deben considerar las experiencias de sus estudiantes. Los cambios se implementan cuando los estudiantes brindan retroalimentación para mejorar su experiencia de aprendizaje. El estudio que se presenta utilizó una muestra de 101 estudiantes de ciencias en computadoras de una Universidad pública en Puerto Rico. Los resultados sugieren que los estudiantes están satisfechos con su experiencia en los cursos que fueron parte de la investigación. El contenido del curso se ofreció 100% en línea. Los cursos implementaron las mejores pácticas de la educación a distancia sugeridas por el Modelo Multi-Estratégico para la Enseñanza Efectiva en Línea. La percepción de los estudiantes sobre la estructura del curso sugiere la efectividad del modelo, ya que describen su experiencia con adjetivos positivos. Los participantes indicaron estar totalmente o muy satisfechos con el aprendizaje adquirido en el curso. Las tres experiencias más significativas para los estudiantes fueron la flexibilidad de estudiar a su propio ritmo con el contenido asincrónico, la organización y estructura utilizada y los videos que presentan el contenido del curso. Según los resultados, el Modelo Multi-Estratégico para la Enseñanza Efectiva en Línea provee una buena estructura para el diseño efectivo de cursos en línea.

Palabras clave: educación a distancia, ciencias en computadoras, diseño instruccional, programación, MEL, educación en línea

Abstract

Institutions offering online courses must consider the experience of the students within their courses. Changes can be implemented when students provide feedback to enhance their learning experience. This research was performed with a sample of 101 students in the computer sciences discipline from a public university in Puerto Rico. Results suggest that students are satisfied with their experience in the courses that were part of the investigation. All content for the courses in this research were offered 100% online. The courses implemented the best practices in online education suggested by the Multi-Strategic Effective Online Teaching Model. The students' perception of the course structure suggests the effectiveness of the model, as they described their experience with positive adjectives. Participants were also totally or very satisfied with what they learned through the course. The three most meaningful experiences for the students were the flexibility to study on their own path with the asynchronous content, the organization and structure used to present the course content, and the videos presenting the course content. Based on the results, the Multi-Strategic Effective Online Teaching Model provides a good framework for the design of effective online courses.

Keywords*:* online learning, computer science, instructional design, programming, distance education, Multi-Strategic Effective Online Teaching Model

Introduction

A study carried out in which student's satisfaction with the implementation of the Multi-Strategic Effective Online Teaching Model was analyzed. The model serves as a guide for the online learning process. The research consisted of an analysis of a sample of online courses at the University of Puerto Rico at Ponce in the 2018-2022 period. The main contributions of this paper are the evaluation of the effectiveness of the Multi-Strategic Effective Online Teaching Model as a framework for design of online courses for computer sciences programs and the opportunity to identify strategies recommended by the model, which are meaningful for the undergraduate students. This article presents a review of the literature on different distance education aspects and the Multi-Strategic Effective Online Teaching Model. The methodology used in the research is described and the study findings are discussed. Finally, the conclusions of the research are presented.

Literature Review

Juca (2016) presents distance education as a methodology or educational system of independent, remote training, mediated by various technologies. The author points out that the concept is defined as planned teaching and learning, in which teaching occurs in a different place than learning and requires communication through technologies. It also emphasizes that distance education changes traditional schemes that are part of the teaching-learning process, for the instructor as well as for the student. In this sense, the author considers that distance education requires greater independence and self-regulation.

Previous work published by Ghirardini (2014) stated that course content originally designed by the professor to be used in face-to-face courses should not automatically be transformed into online course material. The main reason is that the online course modality requires specific format and it is recommended that the learning objectives of the course be reviewed before developing the content for the lessons. Likewise, the topics that should be covered and what would be the best way to present them should be reviewed. On this regard, Gutiérrez (2018) established that good course design and student engagement in online learning experiences are important. The author suggested that design can make a difference and keep students engaged in their learning, mainly because the design of distance courses affect the way of communication, the way of interacting with the content, and how the student is guided to acquire knowledge in an attractive way. One of the fundamental areas in distance education is instructional design, as it is considered a fundamental tool for faculty in this modality. The instructional design is used as a planning guide, which allows the content to be adapted to the learning needs of the students (Sánchez, 2017).

Active learning in asynchronous online courses can include three approaches, according to Riggs and Linder (2016). They are: a virtual classroom engagement architecture, the use of Internet-based tools integrated into the Learning Management System, and the use of discussion forums. The authors point out that active learning activities have increased, are more widely accepted, and generate positive attitudes. Other tools have been identified as good strategies for online courses. A study published by De la Fuente (2018) concluded that the use of videos in different formats contributes positively to learning that takes

place in distance modalities. Similarly, Ferrer (2018) identified several advantages in the use of videos to present content in distance learning courses. Among the most important advantages highlighted by Ferrer are: its easy distribution and access anywhere and at any time, as the student can watch the content as many times as they want. Likewise, the student can stop the video when necessary. Ferrer recommends that the duration of the videos should not be longer than 6 minutes, being a recommendation to maintain students' attention.

In distance education, the student is encouraged to be responsible and creative in the construction of their learning. As the student manages to adopt learning strategies and styles, they will learn to learn (Juca, 2016). Ferrer (2018) suggested that the professor should use systematized techniques to record the learning observed by the student, including: rubrics, checklists, number of accesses to the course, time in each lesson, participation, work delivered, or tests taken. According to a recent study (Mohammed, Wakil, and Nawroly, 2018), micro learning method can improve student's learning ability. The study concluded that students were excited about learning and motivated during the lessons to gain more knowledge. It also suggests that students were able to retain information effectively and microlearning aids their long-term memory. Regardless of the distance learning modality, Ferrer (2020) emphasized that learning activities, interactions, assessment and evaluation must be aligned with the objectives of the course. Also, all objectives must be covered and evaluated, and no assessment or content should be submitted for topics that do not respond to any objective for the class. The training and preparation of faculty members for teaching distance courses is another fundamental part, as suggested by experts (Juca, 2016; Ferrer, 2018; Quality Matters, 2019). The authors recommend that instructors should have the technological skills and competencies necessary to integrate instructional activities that allow the stimulation and collaboration of students. Juca (2016) pointed out that the instructors need a good training in distance education, since they are the ones who facilitate the training of students through tools to develop critical and creative thinking.

Quality Matters (2019), an organization that reviews the compliance of distance courses according to accepted quality standards, included the training and preparation of professors as one of the factors of the rubric for evaluation of distance courses. This modality requires training in content design, which allows the use of available technologies for virtual environments for stimulation and regulation of learning, student research activity, and collaboration (Juca, 2016). According to the organization, the revision of a course can impact students of both online courses and face-to-face courses. This is because the people who are involved in the review of an online course design learn during the process, and the knowledge they gain helps them improve their courses design regardless of modality.

Research performed at the University of Puerto Rico at Ponce (UPRP) agrees with the training and preparation need highlighted by Juca and Ferrer. In order to explore the experiences of faculty offering courses in the distance modality, López (2019) conducted a study in which the perception of faculty was evaluated. The institution selected Moodle as the institutional Learning Management System for online courses. The results of the study

suggest that students should be oriented on the courses offered in the distance modality before the enrollment process is completed, including details on the minimum equipment required for the course. The study also recommends the training for the faculty so that they develop the necessary skills in effective instructional strategies in distance education, in addition to knowledge in the Learning Management System. Further research summarizes the efforts from the institution related to different trainings completed by faculty members and certifications in distance education. López (2021) found in her study that ninety-seven percent (97%) of the professors of the UPRP who completed a certification in distance education indicated that they were satisfied with the learning obtained.

Multi-Strategic Effective Online Teaching Model

Contributions of Mayer (2014) are part of different principles and model related to distance learning that must be considered. Mayer established, through theories and principles, an important relationship between multimedia resources and deep learning. The author suggests that people learn best when words and pictures are used rather than just words. The cognitive theory of multimedia learning establishes five cognitive processes involved in multimedia learning: (1) the selection of relevant words, (2) the selection of relevant images, (3) the organization of selected words, (4) the organization of selected images, and (5) the integration of verbal and pictographic elements into existing learning (Mayer, 2014). Mayer's theories have been considered by Ferrer (2020), who developed the Multi-Strategic Effective Online Teaching Model. Ferrer presents in a simple way how to design distance courses, transmitting general ideas so that it can be replicated by others. The model guides the selection of technologies, but specific technologies are not recommended in the model as the author acknowledges that technologies change and improve. The model is presented as a pyramid of three equally important components for effective online learning: the structure, educational techniques, and educational strategies. The three areas offer the ideal structure so that the student can concentrate on learning and not be distracted or burdened their cognition in searches within the course. Ferrer points out that the student will be focused on the course content and technology will become more invisible.

In his model, Ferrer (2020) suggests to create a topic, lesson or module for each week of class. The professor must include the content, interaction, evaluation, and assessment activities during the corresponding lesson. Topics should include the following: header and introduction, content lessons, and final lesson. The header section includes general course information, announcements, general details, contact information, frequent links, and other information the student may need more frequently. In the introduction, the professor describes important details of the course, minimum technological requirements, as well as links or support contacts. This section must be visible at all times. The author recommends to include a presentation activity between the students and the professor. The forum allows students to identify areas of need from the beginning and/or negative aspects that can prevent the student from completing the course, while the professor can listen to the particular needs of the students. The introduction section should also expose the student to technologies.

Content lessons include the presentation of the material that corresponds to that lesson, interaction and evaluation. As part of the structure, the model recommends a final module or lesson. The uniform structure in online courses and its corresponding modules helps the student to be more focused on their learning, without distractions. It also recommends to manage 100% of the course using the Learning Management System, including all group or individual communications. The professor must also calculate the expected time for the course activities to ensure that the course does not exceed the contact hours. He recommends to survey the students about the time spent on course activities during the first course offering to gradually adjust it as appropriate. The Multi-Strategic Effective Online Teaching Model also suggests posting lessons on dates expected by students. According to the author (Ferrer, 2018; Ferrer, 2020), keeping all the lessons and assignments of the course open so as not to have to publish them as the weeks go by is a bad practice that can result in stress for the student. The organization described of an online course has been empirically proven to help reduce the student's unnecessary cognitive load.

The second component, educational technique, is defined as the means by which information is transmitted. In relation to educational techniques, the Multi-Strategic Effective Online Teaching Model recommends four techniques. The techniques recommended by Ferrer (2020) are based on literature and research, which have proven to be more empirically effective: video learning, micro learning, social learning, and mobile learning. The first educational technique is video learning. It uses recorded video as its main medium, which uses visual and auditory cues. Visual cues in educational videos help aid in the process of creating mindsets that are necessary for memorization and understanding. Ferrer suggests that video learning reduces the cognitive load, since instead of reading large amounts of text, it is more relaxing to watch it, and the images are processed by the brain faster than the text. The second educational technique is micro learning, which is based on the neurological principle that has proven that information, when acquired in small, separate amounts, is better processed by the brain. The studies on which the Model is based suggest offering information in short segments. Otherwise, very long content overloads the student's working memory and prevents it from passing into long-term memory.

The third technique recommended by Ferrer (2020) is social learning, which refers to memorable information and reflection. Social learning theory is designed to tailor learning to individual student needs and preferences. Students' motivation and desire to learn should be increased. The model points out the importance of building positive relationships between faculty and students, which facilitates a positive learning environment with motivated students. The fourth educational technique is mobile learning, which refers to the student's ability to learn anywhere. In courses with asynchronous content, students have the opportunity of completing the course activities at their most convenient time, an advantage to those students who work and an advantage for courses with students in different time zones.

Methodology

Governing Board of the University of Puerto Rico (2020) defines an online course at the Institution as a distance learning course that offers 100% of the total

hours of instruction through the Internet, so that the entire content, the activities, and learning resources of the course are accessible through the Internet. Using this definition, an investigation was performed with a sample of online courses from the Computer Sciences Department at the University of Puerto Rico at Ponce. Three courses were part of the research: Auditing and Control of Information Systems, Application Programming, and Special Topics in Informatics where the topic covered was Digital Forensics. The research was carried out for four years. The Multi-Strategic Effective Online Teaching Model for the creation and delivery of the content. All content for the courses in this research were offered 100% online, mainly asynchronous, and the student did not have to attend any face-to-face meetings. The courses implemented most of the best practices suggested by the Model. All course lessons opened and closed on a particular day (every week). The content was presented in a logical sequence, that is, in the order in which students should review it. Most course lessons include video learning, which were created specifically for those courses. Interactive videos with assessment questions were included while the content was presented. Also, tutorials in pdf format were included, as well as video tutorials with screenshots, videos with content experts invited by the professor, infographics, and content pages in Moodle, among others.

An instrument was designed in Google Forms by the researcher and reviewed later at the Office of Planning and Institutional Research. At the end of each course, students were provided with the link of the questionnaire on the Moodle platform. Students were unaware of the model used for the course structure. The instrument included general information from the participants and satisfaction with the learning process. It also included open-ended questions about the most significant experience for them, the least significant experience for them, what recommendations they can provide to enhance their experience at the course, and any additional comment they would like to share about their experience in the course. The students answered the questionnaire voluntarily, usually for the last two weeks.

One hundred and one (101) students from the Computer Sciences Department composed the sample for this research. The curriculum is offered face-to-face; nevertheless, some core courses and electives are available for the students online. The data was collected during seven academic semesters from a total of four academic years: second semester 2018-2019, and first and second semester of academic years 2019-2020, 2020-2021, and 2021-2022. The study population is made up of 4 courses, with a total of 156 enrolled students.

Result Analysis and Discussion

A total of 101 students (n) out of 156 completed the questionnaire of the study, which correspond to a response rate of 65%. Seventy-six percent (76%) of the study sample corresponds to male students and twenty-four percent (24%) to female students. Most of the students (91%) do not stay at any housing while studying. Sixty-two percent (62%) of the students do not work, nineteen percent (19%) work 1 to 10 hours weekly, eleven percent (11%) work 11 to 20 hours weekly, six percent (6%) work 21 to 30 hours, and two percent (2%) work 31 hours ore more weekly. Considering only students who work, 55% of them had daytime shifts, 12% had nighttime shifts, and 33% had rotating shifts (daytime and

nighttime). The sample consists of seventy percent (70%) of students in their fourth year of study or more and thirty percent (30%) of students in their third year of studies. There were none students on their first or second year, as courses included in the study were offered during the third or fourth year of the bachelor degree.

The highest percentage of participation on the study was from the first semester of 2019-2020, corresponding to 33% of the sample. One hundred percent (100%) of the sample had used Moodle before completing the course, while sixty-seven percent (67%) had taken an online course in previous semesters. Students were asked to assign a grade to their experience during the online course, using a scale from 0 to 100, with an average of 92%. The averages for each semester were: 93%, 94%, 89%, 93%, 89%, 98%, and 96%. A detailed analysis of the results shows that the lowest two percentages (89%) corresponds to programming courses, while the highest two percentages (98% and 96%) correspond to courses that cover mainly theoretical concepts. The analysis shows that most of the students gave their experience a high rating. Participants were asked to indicate how much they agreed with various statements related to course structure and learning strategies. Most of the participants agreed with the statements provided. One hundred percent (100%) of the participants considered that the structure of the course has a logical order and is easy to understand and access its contents, 97% considers the course provides varied activities that facilitate their learning, 99% taught that the course provides the objectives of each lesson in a clear way, 100% of the participants agreed there is a space to clarify doubts in the different activities, and doubts sent to the professor were answered. In addition, 96% of the participants agreed that distance course activities caught their attention and interest, 98% agreed that the course enhanced their knowledge on the subject, and 97% agreed that the course is visually appealing and motivating. Based on the results, 98% agreed that the distance modality is an effective alternative to offer the course, as the learning objectives can be achieved. The three components suggested by the Multi-Strategic Effective Online Teaching Model are presented within the different items.

One of the questions that the students were asked was how they have felt throughout the course, using adjectives as responses. A list of adjectives was offered as alternatives for them to select the most appropriate, or they can also add a new adjective to the list to describe their experience. For the purpose of this analysis, adjectives were grouped within categories. Most of the adjectives selected by the students were positive (91%), while only 9% of the students selected negative adjectives. Students indicated they felt: grateful or satisfied (28%), excited (26%), confident or guided (24%), and funny or productive (14%). Within the negative feelings, some students indicated they felt: stressed or disappointed (5%), confused or behind schedule (2%), and two percent (2%) of the students provided mixed feelings, one positive and one negative.

In addition to the evaluation of their experience using numeric grade and adjectives, the students indicated their satisfaction with the knowledge gained and what they learned during the course. Most of the students during all academic years indicated they were “totally satisfied” or “very satisfied” with what they learned, resulting in high satisfaction. During academic years 2018-2019, 2019-2020, 2020-2021, and 2021-2022 high satisfaction

was reported (87%, 81%, 82%, and 100% respectively). On the other hand, students were asked about their satisfaction with the online learning modality and the analysis also showed positive results as follows: 48% answered "totally satisfied", 35% answered "very satisfied", 16% answered "satisfied", and 1% answered "dissatisfied".

Students were asked in an open-ended question what was the most significant experience from the course. The content analysis was performed with 41 responses by grouping ideas and comments provided by the participants. Somehow, the components suggested by Ferrer (2020) were mentioned in different occasions. The most meaningful experience was the flexibility to study the course content and perform the assignments based on their preferred time during the time period for each lesson, as suggested by 34% of the responses on this analysis. This result suggests their preference on asynchronous content that students can access and complete within each lecture. This finding agrees with the educational technique of mobile learning suggested by Ferrer (2020). Twenty-two percent (22%) of the participants mentioned the course structure and organization used as their most meaningful experience. Three comments provided by the students in this question were: "The good distribution of the material to be covered weekly, through videos, readings, links and short tests." "I loved the structure of the course, it made it easy and practical to learn about the course." "It is a complete course. It is well organized, the activities have a reasonable amount of time (one week) to carry them out, some of the videos had tests which facilitates teaching, all the lessons had a forum to clarify doubts, among other things." These findings agreed by Ferrer's (2022) suggestion of using a uniform structure.

Twenty percent of them (20%) mentioned the videos as an essential part of the class. This finding coincides with Ferrer (2020), as he suggested within the Model the use of video learning and micro learning as effective educational techniques. Two comments shared by the participants in this question were: "The videos were an essential part of the class. Very grateful that they were explained in the best possible way, to solve the tasks." "The most significant experiences are the videos since they present a dynamic and simple way of teaching." Also, 17% stated the diverse and interesting tasks as their most significant experience on the course. Finally, 7% of the sample identified the discussion forums as their most significant experience where they can discuss with different peers on different topics, learning in a summarized and concise way and clarifying doubts. This finding also coincides with Ferrer (2020), who suggested social learning as an educational technique for building positive relationships between faculty and students.

An open-ended question asked about the least significant experience from the course with 34 responses. The least meaningful experiences for them were related to a specific task assigned within the course. Also, seven responses mentioned the discussion forums, while other seven responses mentioned having doubts during quizzes or assignments as their least significant experience. Forgetting tasks and deadlines was mentioned by 4 and 2 students, respectively. The results barely highlight aspects that need attention related to the course content and structure used. However, it is recommended to provide constant feedback to students so they can clarify doubts as soon as possible, they need to stay connected to their peers and professor, and provide reminders of assigned tasks. Finally, students were asked in an

open-ended question what recommendations they can share to improve the learning experience within the course. Some students stated that there was nothing they could recommend to the course. Other students mentioned specific topics, tasks, or software to be included or enhanced within the course content. Responses that did not mention specific recommendations related to the structure, organization, or educational strategies were excluded from this analysis. Therefore, a total of 27 responses were analyzed and grouped. Six students recommended videoconference where the students could meet with the instructor and their peers. Six students recommended to have reminders integrated in Moodle platform or any type of alert of what assigned tasks they have during each lecture. Four students recommended group projects. Other recommendations were: include more complementary material on pdf format, provide more time for tasks and/ assignments, include additional activities to interact with peers on discussion forums, use more examples for assignments, and use more than one attempt for quizzes. One student recommended to allow the course be completed using a cellular phone. However, the course requires a computer or laptop.

Conclusions

It is important that faculty considers the experience of the students within their courses, read their comments, give value to their expressions and make the necessary adjustments in their courses. On one hand, this research was performed with students in the computer sciences discipline, within their third or fourth year of studies. All of them have previously used Moodle as the Learning Management System. Therefore, the participants had some technical knowledge that helped them lower negative effects of the technology within the online learning modality. Also, the students were enrolled in a face-to-face undergraduate program, so they were not taking all of their courses online. Further studies might integrate computer sciences students within their first and second year of studies to compare and contrast their experiences. On the other hand, results discussed suggests that students are satisfied with their experience in the courses. They stated that online courses offer flexibility of managing their schedule. In general, the Multi-Strategic Effective Online Teaching Model used within the courses included in this research generate satisfaction on the students' experiences and learning process. The results show that courses with more theory involved provided the best experience, when compared to courses that requires coding. However, in average students evaluated their experience with 92%, in a scale from 0 to 100.

The students' perception of the course structure suggests the effectiveness of the Multi-Strategic Effective Online Teaching Model to design courses in the online modality. The majority of the participants described their experience with positive adjectives, such as grateful, excited, confident, and productive. Participants were also totally or very satisfied with what they learned through the course. The three most meaningful experiences to the students were the flexibility to study on their own path with the asynchronous content, the organization and structure used to present the course content, and the videos presenting the course content. Although some experiences were identified as least meaningful, each of them was only shared by one or two students. All of the participants' feedback were considered to improve the course for future semesters. There is no one-size-fits-all for online courses and educational strategies for the

computer sciences discipline. However, based on the results presented, the Multi-Strategic Effective Online Teaching Model provides a good framework for the design of effective online courses. The results show that students were satisfied, they recognize that they are gaining knowledge. Opportunities, such as continuing efforts to develop online courses using the Multi-Strategic Effective Online Teaching Model, can be identified. Results point out the effectiveness of the educational strategies and techniques recommended by the Multi-Strategic Effective Online Teaching Model implemented in the three computing courses of the research. Finally, it is recommended to continue integrating the Multi-Strategic Effective Online Teaching Model within other courses in the program, considering the student's feedback to enhance their experience in the learning process.

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