Strategies for the teaching-learning experiences in the engineering dynamics course based on the information and communication technologies

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Abstract. Technological developments in almost all sectors of industry and/or society has permitted to implement them even in universities by means of it is called ICT. This commits the universities to modify their educational approaches towards those that allow professionals be trained according to what the globalized industry demands today. In addition, it has been taking advantage of the virtual platforms in support of the teaching/learning experiences for the undergraduate courses that facilitate some activities like either the implementation of software of engineering or the student participation in forums or the revision of some concepts which can be impossible to understand in the traditional way of teaching. The Universidad Industrial de Santander (UIS) in Bucaramanga, Colombia, is looking for building a future with a continuous improvement, has undertaken several institutional projects in search of being at the forefront of the pedagogical and social requirements; This study sought to impact the current methods of teaching, and thus achieve a work in synergy with all the university that allows to show the UIS as an entity that continues to promote integrity and quality professionals. This project was divided into two stages. The first included the selection and thematic organization of the course, creating the virtual classroom in the Moodle platform and developing activities and tools that will be used there. The second phase was implementation. Always prioritizing skills training that improves quality and allows the future professional to adapt and meet the requirements demanded by the industry today.

1. Introduction
Currently the world is developing at a rapid pace, generating continuously great social, cultural, economic and technological changes. Technology and education are closely related each other nowadays, and the students are expose to a technologized culture [1]. Therefore, it makes evident the need to train professionals who should be not only adapt, but also anticipating to these changes. In other words, professionals can propose right solutions to these challenges [2]. Higher education has the responsibility to enhance this process, so it involves a great challenge for universities and especially in developing countries. Several studies have been done in Colombia in order to incorporates ICT experience in the classroom [3,4].

The design and implementation of new models, strategies and methodologies to improve the teaching-learning process has been the focus of attention of many researchers in the area. These studies have reported results obtained from the application of these new processes and tools. Some interesting work has been done by Cinar and Torenli [5] where it was used online courses based on student expectations;
Redondo et al [6] used virtual and augmented reality to improve teaching-learning processes in an architecture program; Hauge y Riedel [7] used simulation of games in engineering and manufacturing teaching processes; and Farias et al [8] have implemented remote virtual laboratories to support engineering learning processes. It was seen a tendency in the previous studies to use ICT as a tool to innovate in the teaching-learning processes.

The use of information and communication technologies (ICT) have shown that it can improve not only the teaching-learning process, but also the performance in the working life of the professional [9]. In addition, it has been identified that it improves the teaching abilities of the instructor, changing the educational structure and contributing to the improvement of the quality education [10].

In this scene, the Universidad Industrial de Santander is looking for building a future with a continuous improvement and it has undertaken several institutional projects in search of being at the forefront of the pedagogical and social requirements. This study sought to impact the current methods of teaching, and thus achieve a work in synergy with all the university that allows to show the UIS as an entity that continues to promote integrity and quality professionals.

This project was divided into two stages: 1) it includes the selection and organization of the subject by themes in such a way that it allows to design a virtual classroom in the open-source course management system named Moodle (Moodle™) and development of the first activities and tools that are used there. 2) it is the implementation which focuses in the skill training that improves quality and allows the future professional to adapt and meet the requirements demanded by the industry today.

Engineering Dynamics (ED) is one of the fundamental courses in a Mechanical Engineering program. In addition, ED at UIS is one of the most failed courses in the program. It is thought that there are several causes on the difficulty of the students to get the complex concepts in an easy way. The ICT use have become in a need as a teaching-learning strategy because of the increasing technology during the last two decades. It has been demonstrated that ICT use improve the teaching-learning because of the students feel more motivated, have more interest on learning in such a way that they are involved in an active learning. Nowadays, students have higher IQ but the read less. Therefore, the written information should be short and contain more audiovisual resources in order to catch the attention of students more easily [11].

2. Methodology

Three groups of the Engineering Dynamics course were used for this study. Each course had a different teacher (the three authors of this article) which allow not to cut to the bias of the sample due to different teaching ways. Each course had around thirty students in average. The course was designed using Moodle (Moodle™) which the course management system used at Universidad Industrial de Santander. The design has into account the student outcomes which can be seen in Table 1 and the strategies proposed for the three faculty members teaching the ED course.

2.1. Course design using the course management system Moodle

Table 1 describes the strategies and activities based on: 1) the experiences of the authors in several years on teaching the course, 2) Moodle resources, and 3) several previous studies which implement education strategies [9,12]. On the other hand, the cognitive, attitudinal, and axiological competencies for the ED course are listed in Table 2.

2.2. Learning evaluation

The process for evaluating both the learning and the process of learning was carried out using different instruments like quizzes on-site and online, exams, assignments, essays among others. Table 3 lists the evaluations which were used to observe the student performance. For the implementation of online quizzes, a hundred and thirty questions were developed and the divided into the subjects of the course.
Table 1. The strategies and activities proposed and their relationship with the educational materials and Moodle resources.

| Strategy            | Activity                                      | Educational Materials                          | Moodle Resources |
|---------------------|-----------------------------------------------|------------------------------------------------|------------------|
| Problem solution    | Code development solve ED problems.           | Programming Software:                         | Assignment       |
| Text composition    | Essay about a subject in ED                  | Programming Software:                         | Bulletin board   |
| Managing mistakes   | Solutions of exams: identifying mistakes and correct them. | Books, scientific articles, websites           | Assignment       |
| Project Learning    | Development of a specific subject in Engineering Dynamics | Engineering Dynamics textbooks, videos, and scientific articles | Evidence, portfolio |
| Online evaluation   | Quizzes about Kinematic and Kinect of particles and rigid body | Presentations | Questionnaire |
| Research            | Information in internet and library resources about a subject in the course. | Library resources, Websites | Wiki |
| Teaching            | Teaching-learning process                    | Presentations, blackboard, and software for equation solving | URL, and labels |
| Student assignments | Solving assignments and upload the solution to the virtual room | Library resources, websites, computational engineering solvers | Assignment |

Table 2. Cognitive, attitudinal, and axiological competencies for ED course withdraw from the syllabus based on learning competencies.

| Student outcome | Description                                                                                             |
|-----------------|---------------------------------------------------------------------------------------------------------|
| 1               | Determine the position, velocity, acceleration and total travelled distance by a particle in order to determine the physical aspects of its movement. |  |
| 2               | Represent the movement of the particle in plots and interpret them.                                       |  |
| 3               | Define the relations existing between forces, displacement, velocities, accelerations and mass of particles. |  |
| 4               | Explain the position, velocity, and acceleration of a rigid body.                                       |  |
| 5               | Relate the forces acting over the rigid body and its effect over the shape and mass, in addition its movement in two dimensions. |  |
| 6               | Fulfill all commitments acquired at the beginning of the course with responsibility and ethics.    |  |

Table 3. List of type of evaluation for learning in ED course.

| Evaluation type                                      | Learning / learning evaluation | Resource |
|------------------------------------------------------|-------------------------------|----------|
| Quizzes about concept application and problem-solving procedures | Learning | Questionnaire |
| Quizzes about theoretical aspects                    | Learning | Questionnaire |
| Partial Exam                                         | Learning | Written evaluation |
| Final Project                                        | Learning | Evidence |
| Assignments and essays                               | Learning | Homework |
| Discussion about a subject in Engineering Dynamics    | Learning | Open forum |
| Perception about using ICT as a support for learning  | Learning | Survey  |
3. Results

Moodle resources were known after several workshops offered at Universidad Industrial de Santander. The course was divided in six tabs according to the subjects: 1) A presentation of the course, 2) Kinematics of particles, 3) Kinetics of particles, 4) Kinematics of Rigid bodies, 5) Kinetics of rigid bodies, and 6) Kinetics of rigid bodies: Energy and Impact.

3.1. Implementation of the engineering dynamics course in the Moodle platform

All the strategies and activities proposed in Table 1 were implemented at the Moodle platform. There were several strategies that appear in each tab in Moodle as can be seen in Figure 1. These are: A) a picture referring to each subject to gain the attention of the students, B) Wiki, C) Presentations for each class, D) Suggested computational problems, E) A case of study, F) Forum about concepts, H) Online quizzes, Part G) is optional.

![Figure 1. Print-screen of the subject “Kinematics of Particles” implemented in the Moodle Platform. It is shown several activities proposed in Table 1.](image)

3.2. Online evaluation perception

Online quizzes represent an important tool because they allow a formal evaluation of the contents in a more practical way. A survey was applied to the student (n = 20) to have a perception of the students
regarding this type of evaluation and compare it with the traditional way. The responses are shown in Table 4.

**Table 4. Results of the survey for online quizzes.**

| Question                                               | Responses                  |
|--------------------------------------------------------|----------------------------|
| Did you like online quizzes??                          | YES 85% NO 15%             |
| Why did you like online quizzes??                      | Because we know the grade immediately 5% NO 10% |
| Would you like to take more online quizzes?            | YES 65% NO 35%             |
| Would like to take an online partial exam?             | YES 30% NO 55% DEPEND ON 10% |
| What the last question depends on?                     | Enough time to solve it 70% NO 15% |
|                                                        | Difficult rate type of answer Weight in the total grade 5% 10% |

Some interesting results are withdrawn from the survey. Most of the students liked to take online quizzes because the grade is given to them once they finish the test and they do not wait until teacher grade them manually. Some of them (25%) liked the online quizzes because the answer can be chosen from multiple answers. They also respond positively on the possibility on taking an online partial exam. However, time is the major concern (70%) on taking an online partial exam.

4. **Conclusions**

It was possible to develop the instructional design of the Engineering Dynamics course taking into consideration the training based on competencies with an inductive learning style. The learning object was developed for the 5 general themes of the ED course in Moodle by representing the fundamental pedagogical tool that justifies the improvement in the rate of approval of students, the disposition and motivation to take the course.

The object of learning developed allowed to see students participating in the construction of their own knowledge through the various tools they find in an autonomous way with the motivation to achieve all the competencies. In addition, the learning object greatly benefits teachers by generating a sequential, complete, unified and modern teaching methodology. Besides the benefit of an easy follow up to the teaching process because of a faster grading of some evaluation activities that Moodle synthesizes with tables and general diagrams of results.

On the other hand, the use of ICT in the teaching/learning process allows versatility in the way of presenting the contents and in the form of interaction of the student with them due to the different possibilities of presenting an idea or concept (videos, animations, diagrams, use of the web). It promotes collaborative learning between teacher-students and provides the teacher to continuously implement new technological tools which improve their process as an educator. In the same way, the teacher is also exposed to a teaching environment in which Moodle has demonstrated to be one of the most important course management system that is available to higher education for the implementation of learning objects or simply to execute activities that complement the classes in the classroom, for example online questionnaires. It presents a simple and well-known interface for most students, facilitating a positive impact on the new methodology.
Future studies can be done in other courses of Mechanical Engineering program and also uses more elaborated online quizzes that allow to teachers to grade not only the answer but also the solution process in engineering problems.

Acknowledgments
The authors deeply thank to the Mechanical Engineering students at UIS whose took part in the survey, especially to Oscar Florez and Walter Valdivieso for their valuable help on this study.

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