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## Special Issue
## Simulators for Engineering Education and for Professional Development
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## Thomas T. Hewett, Drexel University

*The main objective in developing the simulator presented in this paper is to assist undergraduate students to learn about the analysis of motion behavior in bipedal robots by exploring an approach based on fuzzy-symbolical variables. This approach facilitates learning about and understanding of motion behavior using symbolic reasoning instead of numerical reasoning, such as that based on the analysis of moments and forces, which are difficult to grasp. An important educational aim of this simulator is to develop cognitive skills such as analysis, the construction of structures and generalization. In addition, the simulator helps students to develop an aptitude for self-directed learning as the students themselves build the rules that help them to understand the behavior of motions. The simulator has been built to interact with two real bipedal robots that have 12 degrees-of-freedom (DOF). Experimental results showed that the students were able to understand and analyze motion behavior and then predict the risk that the robot would fall as they interacted with the simulator by reasoning using symbolical variables and their relations. In addition, students developed their cognitive skills throughout the learning process.*

**Keywords:** cognitive skills; bipedal robots; robot motions; fuzzy relations



*A web-based virtual robot task simulator has been developed and used in the teaching of robotics through lab demonstrations and a set of lab assignments. The simulator allows a high degree of real time interaction with a virtual robot that can be commanded to perform a number of pick and place operations on virtual objects replicating an existing industrial robot manipulator. A unique characteristic of the system is that, apart from using high level robot motion commands like the real robot, it allows a simplified graphical input of target positions and orientations to define a gripper path. It also encourages interaction and collaborative problem solving. Empirical evidence shows that the effectiveness of the learning program is increased by the enhanced motivation and interest of the students and through their improved learning capabilities.*

**Keywords:** Virtual reality, robot task simulator, teaching robotics, web-based virtual lab



*We have developed a simulation-based hands-on approach to actively engaging students in learning lean manufacturing principles and tools. In this innovative approach, student teams assemble Lego cars with 45 components in five work stations. The purpose is to demonstrate a variety of benefits from lean production and to provide students with opportunities to improve processes through hands-on experiential learning. Quantitative and open-ended questions were developed to survey student attitudes and experience with the simulation. The results show that over 90 per cent of the students rated their overall experience as positive or highly positive.*

**Keywords:** Lean Lego simulation; active engagement; lean manufacturing



*One of the most essential competencies that all mechanical engineers need to acquire during their studies is the ability to model and simulate problems and mechanical systems, in order to be able to predict the influence of parameter changes and optimise the solving of any problems. Simulation programs such as 'Simulink' can be applied in Mechanical Engineering, not only as Design tools but also for Teaching. The Simulink models that have been developed to supplement theory classes can be at the students' disposal, so that they can check the influence of changes on different system parameters and properties. The theoretical study of the 'stick–slip' friction phenomenon, which appears in some low-speed contacts, and its simulation using Simulink is presented. The influence of parameter changes is also presented and explained as an essential part of the Design Criteria. In the 'Machine Vibration and Noise' course at Universidad Politécnica de Madrid, several Matlab and Simulink simulators of real problems related to vibrations in machines or installations are being used as teaching tools. The 'stick–slip' phenomenon simulator is detailed as an example.*

**Keywords:** Mechanical systems simulation; Simulink and Matlab; educational innovation; 'stick–slip' phenomenon



*For accurate knowledge of a synchronous generator characteristic it is essential to have an idea of its operation conditions. This paper presents an approach for teaching electric machines used in the laboratory specially designed exercises that can be done with MATLAB-SIMULINK. This MATLAB-SIMULINK-based technology will simulate a synchronous generator in order to determine its performance characteristics. By using a prepared simulator, four groups of students have been tested via designed question sheets to determine the effectiveness of the method for teaching the synchronous generator performance concept. This evaluation is very positive in terms of students' developing confidence and their better understanding of the tests and theoretical concepts.*

**Keywords:** MATLAB-SIMULINK, synchronous generator, power factor, load



*The paper analyzes the different approaches of experiential learning theories, applied in the theoretical framework of experiential learning through project management simulation games. As a key element of this research, PROSIGA, the simulation game in which several situations relating to a project management environment can be experienced, is used. The empirical analysis of 102 participants has shown very significant results, allowing the conditions under which the participant can achieve optimum experiential learning to be determined. It is also worth pointing out that mistakes are part of their experiential learning process, dissatisfaction providing a key learning mechanism, demonstrating one of the main strengths of simulation games.*

**Keywords:** experiential learning; simulation games; serious games; learning conditions; empirical study; project management



*One of the core courses in the undergraduate mechanical engineering curriculum has been completely redesigned. In the new numerical methods course, all assignments and learning experiences are built around a video/computer game. Students are given the task of writing computer programs to race a simulated car around a track. In doing so, students learn and implement numerical methods content. The paper describes a preliminary study to measure student engagement. Results show that students 'playing' the video game in their homework are significantly more engaged than when working on homework in other engineering courses.*

**Keywords:** video game; serious game; simulation; numerical methods; mechanical engineering; student engagement

*This study provided a statistical model to assess varied types of Web-based simulations in a digital-filter design course. Ninety-one undergraduate students participated in an experimental study. Two independent variables were studied: Web-based simulations (batch-based, comparison-based, and interval change-based simulations); and prior Internet familiarity (high and low). Two dependent variables were measured: a knowledge achievement test, and a problem-solving belief test. The experimental research design of the study was a 3 × 2 randomized post-test design. Multivariate Analysis of Variance (MANOVA) was used to analyze collected data. The main effects and the potential interaction of the two independent variables were examined. Results indicate that Web-based simulation with a simple batch-based design yielded a significantly better learning performance than two other complex simulation designs (comparison-based and interval change-based simulations) ($F[2,85] = 4.274$, $p < 0.05$).*

**Keywords:** Digital-filter design, e-learning, Web-based simulation.



*To teach and explain system modelling in a Thermal-Fluid application is a challenge: learning how one component or even the surrounding conditions can influence the performance of the rest of the components of the system and the system itself is not an easy task. However a suitable educational implementation may help students gain a deeper understanding not only of the system itself but of the existing interrelation between the Thermal-Fluid fields: Thermodynamics, Heat Transfer and Fluid Mechanics. In this study a refrigerating cycle simulator is used. The simulator is prepared in such a way that the interrelation between each component, the system and the surroundings can be* analysed *by the students. This case study is found to be very useful due of its ability to study system performance. A three-step educational implementation, the simulator being the third step, has been used and found to be enriching both for students and instructors.*

**Keywords:** refrigeration cycle; virtual lab; simulator and system modelling



*Following previous research on the effectiveness of simulators in teaching project management, and research on the impact of history recording mechanisms on learning and forgetting, at individual level and at team level, this study focuses on the functional fidelity of the simulator. The simulator with high functional fidelity used in this study had two advanced project management functions: the ability to hire/fire employees and the ability to split activities. A group of 199 industrial engineering students were divided into two main groups with only one group having access to the advanced functions. Within each group the students were subdivided into sub-groups that used three different history-keeping modes: automatic (simulator-controlled), manual (student-controlled), and a third mode with no history keeping. All the groups used the same scenarios for training. The performance of participants who were running the simulation with higher functional fidelity (i.e., with advanced functions) was significantly better than that of participants running the simulation without these capabilities. Furthermore, the students' decisions on when to record the history during the training process had a particularly strong enhancing effect on the learning process.*

**Keywords:**

# Part II
# Contributions in: Mechanical Engineering, Chemical Engineering, Computer Engineering, Aeronautical Engineering, Active Learning, and Enrollment Management



*This paper describes a spreadsheet-based approach for the calculation of the component matching in a gas turbine engine. The spreadsheet solution is based on a classic, graphical method, so it can easily be understood by the student. The student can concentrate his attention on problem fundamentals and the solution, since no calculation effort is needed on his part. The teaching methodology has been satisfactorily used with Mechanical Engineering students, whose feed-back is summarized.*

**Keywords:** Gas turbine engines; power plants; spreadsheet; mechanical engineering



*This paper introduces the electronic Portal, reports on the experiences of its use, shows how it motivates students towards more successful study, encourages lecturers to give better lectures, enhances learning, and so reduces workloads. A group of students from the Department of Chemistry and Chemical Engineering in Maribor have used this Portal in their Process Synthesis Course for the last four years. Their responses to e-learning and the Portal were collected by means of a questionnaire. The students thought that the Portal was an effective tool that helped them to improve the quality and efficiency of their studies. They thought a combination of lectures and e-learning to be the most suitable solution for them because it gives a freedom of choice in methods and time devoted to studying. They suggest that this kind of arrangement would be beneficial for use in the future. These statements could motivate college students to choose studies at departments that use modern technologies within the educational process and thus increase the enrolment in those departments. The faculties' responses to using the Portal are also presented. The results of their questionnaires were not as encouraging as the students'. A few lecturers had already used certain functions of the Portal but, in general, they thought that the incorporation of e-learning into the educational process means a heavier workload and is time-consuming. Perhaps the experiences of the lecturer for the Process Synthesis Course, who has been using e-learning for several years, will demonstrate that the incorporation of e-learning into the educational process leads to a heavier workload at the start, but this reduces over time. Perhaps this experience will encourage the faculty to reconsider.*

**Keywords:** ICT, electronic tool; e-learning; chemical engineering courses

*In the automation field, the coursework assignments are basically automation tasks that follow real systems. The reason why students need to work under this practical approach is because there is a constant need for industry-focused qualifications for new entrants to the job market. A practical orientation towards industry needs is required. However, many universities cannot afford the appropriate laboratory equipment to develop the required practical skills. A possible solution is to use computer emulations to support hands-on education and training. At the ITESM Tele-Engineering laboratory, emulated models have been developed and used for the last three years.*

**Keywords:** automation; computer simulation; laboratory education; plc programming



*A teaching experiment was conducted with students of Graphic Engineering at Madrid Polytechnic University Aeronautical Engineering School to improve their professional development in cooperative engineering design tasks in an aeronautical company. A matrix-like company structure made up of departments interacting on different projects was created. This means that the students had to collaborate and share design information. This paper describes how the experiment was organised, how it developed and the most significant results. Considerable quantitative and qualitative improvements were observed compared with the traditional methods that were used on previous courses.*

**Keywords:** design; education; teamwork; cooperative design; aeronautical design



*The purpose of this case study is to present an alternative way of teaching, using demonstrations as a teaching aid. A system for visualisation and demonstration of fluid mechanics, particularly laminar and turbulent flow, has been developed, used, and evaluated in a basic fluid mechanics course for students in Mechanical Engineering. The idea underlying the demonstrations was to enhance the students' conceptual understanding of phenomena that emerged in fluid mechanics. In order to investigate the outcome, we asked the students from two different groups to fill out a questionnaire in a 'cross-sectional' manner. The results indicate that demonstration-based education had increased the students' motivation and probably enhanced their learning. This could imply that the student moved from a 'surface approach' to a deep-level approach to learning.*

**Keywords:** active learning; conceptual understanding; demonstrations; fluid mechanics



*In this paper, we describe the guidelines for active learning activities for courses that share a final interdisciplinary project. Our observations are based on the interaction by students from two disciplinary contexts during the development of an academic project, specifically the design and assembly of a fully functional consumer electronic device. During this process our main objective was to put into place good practices for the combination of industrial design and electronic engineering disciplines using collaborative and active learning techniques. It is our intention to present the results of our studies and methodology as a reference for further experiments in the same line of research or as a case study for other disciplines.*

**Keywords:** interdisciplinary; industrial design; electronic systems; computer mouse; RIRReD



*In this paper, we present two consecutive Data Envelopment Analysis (DEA) models to measure the relative efficiency of applicants to graduate programs in engineering and to compare these efficiencies with the success of these students in the program. The proposed performance criteria are determined depending on the current evaluation criteria in the School of Engineering at the University of Bridgeport. The steps and implementation of the proposed methodology are explained with the help of a numerical example for the Fall 2004 semester.*

**Keywords:** graduate enrollment; engineering; decision making; engineering education; Data Envelopment Analysis.