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Improvisation of Circuit Design and Analysis Skills of students for Analog Electronics Course Using Virtual labs

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Abstract: In this paper we describe the effect of using Virtual lab for electronic circuits, namely, DoCircuits on the circuit design and analysis skills of second year engineering students of Electronics and Telecommunication program. We present the results of a control group-experimental group study. As part of the study, the students performed two experiments using Virtual labs along with hardware. Experiment design guidelines given in the online SDVIcE too are used. This was followed by a post-test, end semester laboratory examination, survey and interviews. The analysis of students' scores in the laboratory examination and post-test indicate an improvement in the circuit design and analysis skills of students. The results of the survey and interviews indicate that the students perceive that performing experiments using the Virtual lab helped them in conceptual understanding and improving their circuit design and analysis skills due to the various affordances provided by the Virtual lab.

Keywords: Simulation tool, Virtual labs, circuit design, circuit analysis

1. Introduction

In engineering education, hands-on experience is very essential for the students as one get exposure to design, implementation and testing. The laboratory work provides opportunities to the students through which they can develop these skills. The instructors can design the laboratory experiments with learning objectives targeting the analytical and design skills amongst the students. This paper discusses the details of the experiment we carried out with 142 UG engineering students for the course Analog Electronics. We used Virtual lab software 'Do-circuits' and the online guidelines provided by the SDVIcE tool available at http://vlabs.iitb.ac.in/vlab_tool_alpha/. It helped us in designing experiments. Both experiments were designed with learning objectives targeting the circuit analysis and design skills. The guidelines in the SDVIcE tool also helped us in designing the assessment questions aligned to the learning objectives. The Virtual lab software selected for the purpose of the experiment has all the necessary features required for the performance of the two experiments. After the design of the experiments all the 142 students performed these experiments using the Virtual lab software during the allocated times of the regular laboratory sessions in the semester July to November 2017. To find out the perceptions of the students regarding the usefulness of the Virtual lab software in the development of analysis and design skills an online survey was designed by the instructors who taught the laboratory course along with the educational technology expert. Online survey was administered to the entire batch of students.

2. Literature Survey

In traditional teaching methods, students learn within a classroom with the help of lectures, notes or by using textbooks. Teachers are often encouraged to incorporate new instructional strategies such as active learning, showing live simulations, animations, videos, pictures etc., so that students participate in their own learning. Active learning is a learner-centered approach that encourages

student involvement in the process of learning. Rather than being passive listener, students become active participants [8]. In active learning teachers are not "deliverers of knowledge" but rather "facilitators." Active learning environment gets support from various factors like well planning, enthusiastic participants, size of the crowd, effectiveness of infrastructure, information and communication technology (ICT) tools and many more. ICTs have been considered as the combination of technologies for gathering, storing, processing, collaborating and distributing information [2].

Modern engineering education is undergoing significant changes, notably in the way engineering institutes are adopting problem-based instruction to meet the changing demands of engineering practice [3]. Simulation is a great example on educational games that could be applied in the context of e learning and has been defined as an "art and science of creating representation of a process or system for the purpose of experimentation and evaluation" [1]. It is the process of reproducing a procedure where learner can apply his knowledge on with no risk and by saving time and money. Virtual laboratories simulate on-screen the experiments that are traditionally performed in real laboratories.

E-learning platforms present several advantages as it enhances student-centered learning; students become more self-sufficient while educators take on innovative roles. While face-to-face learning is better for ordinary discussions, contributing to an active environment, e-learning enables students to receive learning activities from educators at a distance, allows larger classes and it is easier to identify and record behaviors and errors to improve learning activities [4].

3. Sample and Procedure

The sample consists of 142 Second year U.G. students from Electronics and Telecommunication engineering (EXTC) program of the self-financed autonomous engineering college affiliated to University of Mumbai, India. The researchers are the instructors conducting the entire laboratory and theory course of analog electronics I for EXTC program.

3.1 Selection of Course, Virtual lab and Experiment:

Analog Electronics I is a core course for EXTC engineering program. This course covers important concepts in electronics engineering and is prerequisite for higher semester courses. The course demands clarity of concepts so that one can design and analyse electronic circuit. Instructors reinforce the concepts taught in the theory class with experiments in laboratory session. Due to the user friendly nature and different features provided by the 'Do-circuits', we made a decision to use it for the purpose of our experiment. Using 'Do-circuits' one can build, analyze and share Circuits on the web also. 'Do-circuits' has its own Web forum, which provides support to students and researchers all around the world, thus resulting in an almost unique example of simulation tool over the Internet. The learning objectives for the two Virtual lab experiments are:

1) Student should be able to analyze and design voltage regulator circuit using Zener diode
2) Student should be able to analyze BJT amplifier in Common Emitter configuration

3.2 Research Design, Instruments used and Data Gathered:

The research design used was control group- experimental group with performance of students in the end semester laboratory examination and post-test as a measure of intervention followed by survey questionnaire and interviews. The scores obtained by students in the end semester practical examination and post-test are considered as the dependent variable for our study. At the end of semester, survey questionnaire was administered through Google form. Students completed the survey individually without any bias of peer or faculty.

The instruments used for the study are: End semester laboratory examination papers, posttest paper and the survey questionnaire. Data was gathered for analysis is Students' responses to the four point Likert scale questions and open-ended questions in the survey questionnaire and interview. The data analysis techniques used in the study is the comparison of means using t-test and ANOVA for the quantitative data and content analysis for the qualitative data.

4. Results and Conclusion

Independent samples t-test was carried out on the scores of students in the end semester practical examination. Results of the analysis are significant as $p < 0.05$. Analysis reveals most of the students agree that, the simulation helped them to design and analyse BJT amplifier and voltage regulator. More than 90% of the students are able to identify the type of regulation correctly from the given graph. Nearly 47% of the students scored more than 75% of the marks in post-test. Features of Virtual lab software, which students felt useful are sweep, ease of construction/connection, ease of plotting graph and auto variation of parameters. About 97 % of the students confirmed that Virtual lab experiments helped them in conceptual understanding.

The performance of the experimental group students was better than the control group students. Further there was a statistically significant difference in the scores of the two groups of students. Simulation was also used during the lectures, which made the concepts very clear as per the interviewed students. The actual working of the circuit when certain parameters are changed is more visual and interesting for understanding the concepts. In order to get a deeper understanding of the perceptions of students regarding the usefulness of the simulation tool in the circuit design and analysis skill we conducted interviews of 20 students in groups of two or three each. Interview data was analyzed using the content analysis method. The results of this analysis are in-line with our hypothesis.

5. Limitations

All hardware experiments were not simulated due to time constraint of two-hour laboratory session. Breakup of marks for students examined for these experiments could not be separated from available data of practical examination marks. For the better understanding of research results obtained pre-test would have been additional tool. We plan to carry out a pre-post test study in the next semester as a future work.

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