Smart Learning Environments for Teaching Electronics to students

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Abstract— **The paper presents an alternate approach of teaching electronics by hands on activities instead of the conventional approach of classroom lectures and structured lab sessions. The current work applies the notion of Butterfly Model in developing three Learning by Doing (LbD) courses in Electronics viz. Digital System Design Using Verilog, VLSI Architectures, Topics in Embedded Systems. The effectiveness of these courses has been tested in the classroom on a population of 250 students with around 195 people giving positive feedback.**

Keywords- Learning by Doing, Electronics, Butterfly Model

I. INTRODUCTION

With a proliferating growth in the number of engineering colleges in India there is an acute scarcity in the availability of trained teachers. This coupled with lack of funds to buy and implement practical training aids for students, has added to the problem of shaping a good learning environment to teach engineering. Electronics, being a highly practical oriented subject, teaching it without any practical training is almost impossible.

The authors developed Learning by Doing (LbD) courses based on the Butterfly Model [1]. Earlier course content that was developed followed the Cronje's four quadrant approach of learning [2].The proposed model of smart learning has been implemented in three courses viz. Digital System Design Using Verilog, Topics in Embedded Systems and VLSI Architectures through the approach mentioned in [1]. It allows for more personalization and more student involvement in the content. The most important aspect of having LbD methodology as the basis is "skill gain" which has been mentioned in [3].

II. BUTTERFLY MODEL AND ITS IMPLEMENTATION IN THE LBD COURSES ON ELECTRONICS

Butterfly Model has already been stated in [1]. In the current set of courses, the Butterfly Model has been emphasized through the LbD courses, and makes the learners solve assignments and show work outputs. Fig. 1 depicts a picture of the Butterfly Model. The different components of Butterfly Model have been depicted in Fig. 1 [1].

The Butterfly Model has been implemented through three web based learning courses oriented towards Electronics such as Digital System Design Using Verilog, VLSI Architectures, and Topics in Embedded Systems. The components of the butterfly model have been specified in [1]. It is ensured that the learning objectives touch upon
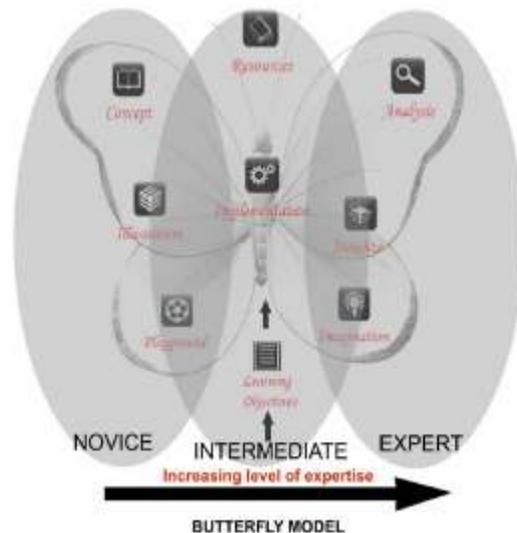

Figure 1. Butterfly model

higher order thinking skills as mentioned in the Bloom's taxonomy [4].

Implementation of concepts through doing hands on exercises is emphasized in each of these courses. The

playground component of the Butterfly Model has been implemented through Virtual Laboratory tools. The following examples illustrate how the Virtual Laboratory practices have been used for hardware modeling in VLSI Architectures course. The idea is to provide a functional description of the system using a Hardware Description Language (HDL). Then the virtual lab tool will synthesize and convert the same into a structural model with interconnections. Let us take the example of a multiplexer which forms the fundamental building block of most digital VLSI circuits. The architecture of the multiplexer is depicted in the Very High Speed Integrated Circuit Hardware Description Language (VHDL) [5] architecture as shown in Fig. 2(a). It is this architecture that has to be coded by the learner.

It is evident from this VHDL description that a student need not worry about the circuitry of the multiplexer and only needs to be concerned about its behavior. In the playground section, the virtual lab synthesizes the circuitry of the multiplexer from the behavioral description. The design of the multiplexer is shown in Fig. 2(b).
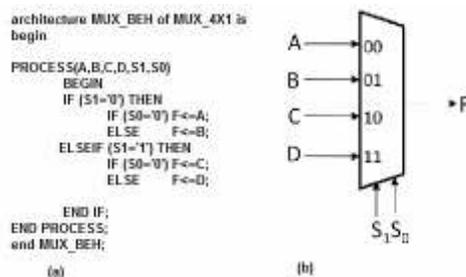

Figure 2. (a) VHDL architecture of the multiplexer. (b) Design of the multiplexer

Once the design of the multiplexer is done, the virtual lab allows the circuit to be simulated using the regular techniques for simulation. This process is very hands-on and practical oriented aimed at Learning by Doing [6].

The justification of hands-on learning is that it enables learners to develop functional learning and develop ability to inquire on their own. Concepts and animations have been provided in the form of video lectures so that learners can suitably refer to them in case they find any difficulty in course of their practice.

Resources in the form of e-books, video lectures, tutorial papers and slides have been provided to aid learning. Tasks and quizzes have been provided at specific points so that learners gain deep insights into concepts by suitably solving them.

In addition to the above, full assessment papers have been provided in the form of two mid-terms and one final exam. This has been done to give a comprehensive classroom like learning environment where the student can learn, explore and test himself.

III. RESULTS AND DISCUSSION

The playground component was used by a group of 250 CS students for 3 months, after which a survey was conducted. Over 80% of the students gave positive feedback about the course content [7].

Extensive trials have been conducted with 50 students participating in Digital System Design Using Verilog course, 52 students participating in VLSI Architectures course and 10 students participating in Topics in Embedded Systems. The feedback has been collected from these students both in the form of tests being conducted as well as the direct feedback from the students. Around 85% of the students gave positive feedback about the course and around 75% of the students showed satisfactory performance in tests.

Results of the feedback clearly indicate the effectiveness with which these Learning by Doing courses in Electronics have been developed.

IV. CONCLUSION

The paper focuses on the aspect of alternate approach of learning Electronics by doing. Rather than going through the conventional ways of aiming at class lectures and practical lab sessions, the authors provide an approach by which students can learn by themselves without classroom sessions. Butterfly Model of learning has been implemented and used to develop the LbD courses. Since the course content is available online, self-motivated students can take benefit of this material. Efforts are on to further improve the pedagogy of the courses based on feedback being received from the learners.

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