Implementation of Microelectronics Track in Electronics Engineering in a Philippines State University

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Abstract *-The evolving trends in electronics continuous to attract students to take upElectronics Engineering.However, it also adds to discipline implementation complexities.Institutions of Higher Learning offering this program must adapt to this realities to avoid obsolescence. This paper looked at Batangas State University, in the Philippines,ongoingimplementation of the Microelectronics track under the Electronics Engineering (ECE)Program. It describes the restructuring done to the ECE curriculum to overcome the enormous complexity inherent in microelectronics design and the teaching pedagogy adopted to promote active learning. The ongoing program has produced encouraging outcomes:1)students were able to design, and simulate complex gate CMOS circuits using EDA tools, in the four(4) course electives identified for the track; 2) the culture of independent learning among students improvement in students soft skills, communication skills, time-management and teamwork skill,; 3.) useof free and web-based tools overcome the issue of high cost of license for EDA tools and seminar/training for continuous upgrading of faculty. Another encouraging outcome was the acceptance of the student-centered teaching approach used, Problem-Based Learning (PBL),in enhancing the students learning experience.*

Keywords: *Electronics Engineering,microelectronics, Problem-based learning, student-centered learning*

INTRODUCTION

Electronicsis one of the top commodity exportsfor the Philippines [1].It is also a top job market. In 2007 alone, it generated more than 24,000 additional jobs. Most of those employed are from engineering, IT, and technical graduates. The sector had an uphill trend from 1995 until 2010 except with the notable dip in 2009 when there was a demand slowdown in electronics.

The Philippine government is focusing on electronics as shown in Table 1. Semiconductor exports make up about 35% of GDP; with electronic goods accounting for 58% of all exports [2].

However, this sector is facing substantial employment issues. Among them is the lack of qualified applicants to fill up vacancies and if it is not the quantity problem, it's the quality. A World Bank survey noted that employersrequire generally skills in problem-solving, communications and management. These skills were determined to increases workers efficiency and productivity [2].

Table1. Priority Sectors in various South-East Asian Countries

Country	Sector Priorities
Indonesia	Coal and Mining, oil and gas, steel, transportation equipment, tourism, food and beverage, shipping, textiles, information technology, defence
Philippines	Information Technology, electronics, shipbuilding, pharmaceuticals
Thailand	Automotive, electronics, aerospace, alternative energy, biotechnology, information technology, medical services, tourism, media
Vietnam	Textiles, shoes and leather, plastics, food and beverage, paper, oil and gas, chemicals, mining

Source: www.britishcouncil.org[2]

Serious gaps in skills and competence of workers were noted in the service industry, export sector, and technologically intensive in the Philippines.

According to the British Council report [2], job mismatch occurs not because of oversupply alone but because of the quality of graduates also. They noted that while the government is pushing for higher tertiary education enrolment, there is a "sub-par" university system that does not meet the demand of the electronics sector. Adding to the problem is the poor quality showing of tertiary graduate in the generic abilities required by emerging industries that will propel growth and productivity -problem-solving, communications, management skills [2]. Hillage and Pollard, as cited by Barte [3], identified the four components of employability – assets, deployment, presentation, and context of personal circumstances and the labor market. Hillage and Pollard further dissected the asset component into three levels, baseline, intermediate and high-level [3]. According to the paper by Barte, baseline refers to the basic skills that and personal attributes of the graduates, intermediate assets are for communication skills and problem solving while high-level assets are for organizational performances like team building, self-management, etc.

It was in this context that the paper utilized an exploratory research design to determine the more effective method of teaching microelectronics with the added aim of improving the generic or soft-skills of students. The offering of the track presented a new area for exploring more active learning methods from students and teaching strategies for the instructors.

OBJECTIVES

The paper aimed to look into how the Electronics Engineering program offered in a State University program was enhanced by offering a specialized track in microelectronics. The paper described a shift in paradigm from teacher-centered to a student-centered, active learning teaching pedagogy. The paper also took into consideration the following issues: what specific courses were to be offered as electives in the Electronics Engineering curriculum? What active learning method would be effective in addressing the "generic skills" gap and what approach can be implemented? What generic-skills will be improved in the implementation? What will be the underlying issues that need to be addressed to make it successful?

Role of Academe

The Philippine government has taken notice of the gap between what this niche industry requires and what academe teaches. The Department of Labor and Employment had published priority jobs that students can take up in their tertiary education. The mandate to promote and develop ICT in the Philippines has provided a strong impetus for the academe and industry collaboration.

On cue, the Commission on Higher Education (CHED) has answered this with CMO 37, series of 2012 [4]. It mandates all IHLs to adopt outcomes-based education (OBE) system to all engineering education. This memorandum order mandates IHLs to pursue "learning by doing" approach. This learning strategy will be student-centered rather than the traditional teacher-centered where learning is limited to what the teacher is giving. An OBE approaches utilizes the learning outcomes in the assessment of students. (CHED) has also started initiating a stronger Industry- Academia Collaboration schemes.

BS Electronics Engineering (BS ECE)

The Bachelor of Science in Electronics and Communications Engineering (BS ECE) degree was first offered as an undergraduate degree program in 1990. Originally, the first two years of the program were under the College of Arts and Sciences while the last three years were under the College of Engineering. Since 2002, the first two year levels were made to be the General Engineering department which was then attached to the College of Engineering, Architecture and Fine Arts [5].

The degree name was changed to Bachelor of Science in Electronics Engineering in the first semester of 2008 for the first year (General Engineering) and therefore 2010 for the third year BSECE. This was due to the implementation of new CHED memorandum order No. 24 series 2008 in accordance with RA 9292 which is the "New Electronics Engineering Law of 2004".

Students admitted and enrolled before 2008 received a BS Electronics and Communications Engineering degree. On the other hand, students admitted in the first year level in 2008 and hence third year level in 2010 will receive BS Electronics

Engineering upon graduation. Batangas State University conferred its first BS Electronics Engineering degree in March 2015 and the last BS Electronics and Communications Engineering in October 2012.

Microelectronics Track

On June 2, 2008, CHED released CMO 24, 2008 rationalizing BS ECE education and prescribing the policies and standards of BS ECE programs [6]. Included in the CMO are the suggested free or elective tracks. Course electives were prescribed to give a certain degree of specialization for IHL to develop strengths in areas where they already have a certain degree of expertise.

This CMO was one of the main reasons why the Electronics Engineering programof Batangas State University was re-structured. The BS ECE offered the Microelectronics track in June 2012. The department previously has only one elective track, information and communication technology (ICT). With this offering, two elective tracks are now available for the students to choose from, ICT and microelectronics. Incoming 4th year students were given the choice of which track they will take provided certain eligibility criteria were met.

Ten (10) courses were identified in CMO 24 that can be offered in the Microelectronics track. For the BatState-U BS ECE program, focusing on Semi-custom Digital Design, the following courses were selected: Elective 1 – Introduction to Digital VLSI Design, Elective 2 – Advance Digital Design with HDL, Elective 3 – VLSI Test and Measurement, Elective 4 – Design. These courses were selected and determined by the department's facility readiness and faculty competence to teach the courses.

Elective 1 – Introduction To Digital VLSI Design

The offering of Elective 1 (Introduction to Digital VLSI Design) started June 2012.The course focuses on the practice of designing digital logic circuits and systems, from schematics to mask layout. While instructional materials were available, it was not adequate for the students to grasp the concept of digital IC designing. Electronics Design Aided (EDA) tools was required to do the layout implementation. Prohibitive cost, however, prevented the state university from procuring the high-end software. The more cost efficient solution adopted was to use free or share-ware EDA tools. They may lack the sophistication of costly equivalent but it will achieve the set learning outcomes.

For this elective, Microwind2 was used. Shown in Figure 1 is a student design of T flip-flop done in Microwind2. Microwind is a Windows-based CMOS circuit editor and simulation tool for digital logic and mask layout-level design, developed mainly for education [7].

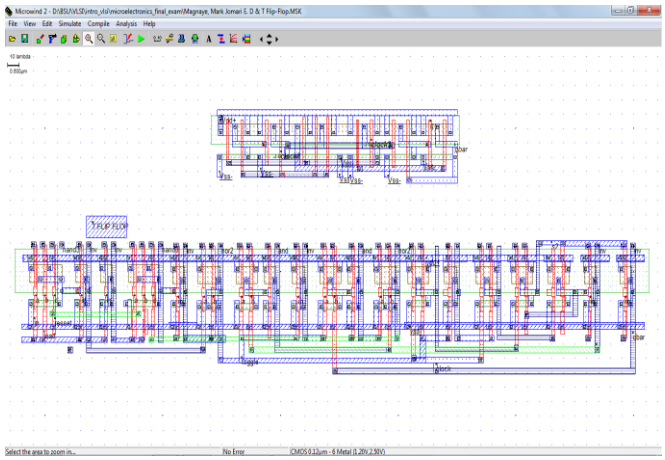

Figure1. T flip-flop design in Microwind2

Elective 2 – Advance Digital Design With HDL

The course aims to teach students Register-transfer-Logic (RTL)-based designing using hardware description language (Verilog-HDL) and FPGA-board synthesis tools. The course focuses on the following: a.) HDL based design methodology, b) the used of Verilog-HDL for the simulation and logic synthesis of a digital design, c) FPGA board implementation, and d.) Soft-core processing.

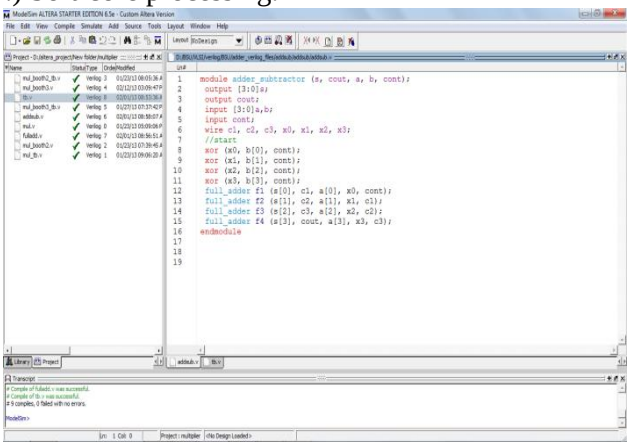

Figure 2. Adder/Subtractor module in ModelSim

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For this course, the EDA tool chosen was ModelSim. It's compatibility with Field Programmable Graphic Arrays (FPGA) made it ideal to show how synthesis is implemented. Figure 2, 3 and 4 shows the Verilog-HDL code, testbench module and simulation result, respectively, in Modelsim of an adder/subtractor design. The course required designs to be implemented in the FPGA board using ALTERA DE-1 Board [8].

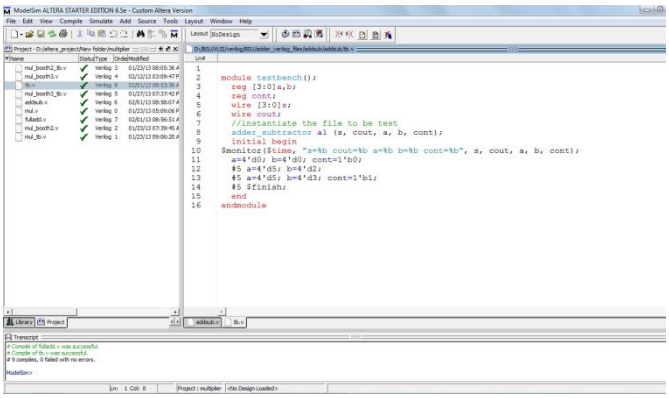

Figure.3Testbenchmodule for the adder/subtractor

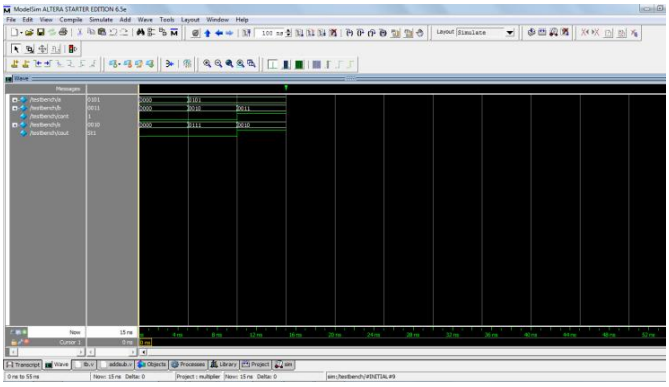

Figure 4. Simulation Result of adder/subtractor

Elective 3 – Introduction To Logic Circuit Testing, Fault Analysis And Verification

This course covers the test concepts, practices and procedures conducted on basic digital circuits. Included were the used of tools and methods. Among the topics covered included: fault modeling; basic fault simulation; test generation algorithms; testability measures; design for testability and scan design; built-in self-test, delay testing; and basic fault analysis. Seminar-type class was conducted with invited industry experts in fault analysis to give the lectures. Educational field trips to partner industries were also done to allow a first-hand look at fault diagnosis and analysis.

Elective 4 – Microelectronics Systems Design

Students taking the class were required to conduct and implement projects with objectives related to the track. The culminating major design was the final output for this elective course in the specialization track.Designs and results were determined considering appropriate engineering standards and multiple realistic constraints. Oral presentation in class served as part of the culminating activity for this course.

Student-Centered Teaching and Learning Strategy

Student-centered learning focuses on the engagement of students in the learning process [9]. While the paper used student-centered approach in an engineering context, it can be adopted in any discipline. Strong emphasis should be on the role shift not only on the students but more on the instructors. Catalano & Catalano (1999) identified the seven (7) new roles of instructors and professors in a student-centered learning[10] as: facilitator of thinking/processing skills; identifiers of level of thinking required by students; developer of questions/activities that facilitates student exploration; developer of visual tools to help students see information interconnections; provider of group-learning activities; user of analogies and metaphors to ease concept learning; and adopter of non-threatening mechanism for indirect dialog between teachers and students.

Among the more commonly used strategies to promote this teaching paradigm is problem-based learning (PBL). PBL approach was adopted by the department to teach the new track. It allows the students to take an active part of their learning [11]. The implementation of PBL approaches has proven to effective in addressing major issues of engineering education: improvement of low employability of graduates and low passing marks of engineering students [12] by focusing not only on the outcome but also on the process, more enthusiastic engagement of laboratory works and lifelong learning [13], the lack of practical exposures to engineering practice [14]can be overcome through a more realistic and industry scenarios where students acts as consultants, and improve communication skills [15] through speaking

engagement from different perspectives via six-thinking hats techniques.

As the students take more responsibility in the learning process, exploring what available information are out there given a "trigger" problem or scenario, PBL allows them to develop their decision making skills by setting their own learning goals. Normally the trigger is an open-ended question which allows students room to explore and seek alternative options before a solution is made. Afterwards, a group presentation of their findings is made to the class.

The department used the Facts-Idea-Learning Issues- Action (FILA) method of PBL .The first three elective were used as PBL triggers. The last elective was purely design course. The used of appropriate rubrics for the oral presentation and manuscripts assures objective assessment of attainment of learning outcomes.

Generic Skills Development

One of the notable features of student-centered learning, through PBL, is the development of skills that will make learning holistic for students. Soft-skills like critical thinking and problem solving, communication and ethics were noted to have improved dramatically in a research conducted at a private Malaysia university [16].

In the implementation of the microelectronics track, these skills were also targeted and the same outcomes were observed. PBL was conducted in such a way that students will be engaging in problem solving activities where open ended triggers will allow them exploration and determine their desired outputs, improving their decision making skills in the process. To facilitate improvement in oral and written communication skills, the PBL activities require documentation and formal class presentation. The assessment was done with a rubric.

Issues and Challenges

The challenge for offering elective courses was that no laboratory hours were allocated. Hence, a more active method was used to facilitate hands-on experiential learning; Problem-based Learning (PBL).

Other early issues identified prior to offering the track were the availability of computer aided tools (CAD) for the courses, adequacy of facilities, andcompetency of instructors who will handle the courses.

The prohibitive cost of the licenses and the limited budget of state universities make it difficult for public state universities in the Philippines to acquire them. The ECE department opted to use web-based or free ware license tools for the different elective courses of the microelectronics track instead. The software Microwind was chosen for elective 1, Modelsim (web-edition) for elective 2 and Quartus II for elective 4.

In order to provide adequate facilities, available computer stations were installed with the software. Competency of faculty members was enhanced through trainings and seminars. The immersion of some instructors in the industry likewise upgraded the relevancy of the courses and served as confidence building to handle the courses better.

CONCLUSION AND FUTURE OUTLOOK

The program is on its third year of implementation and, noteworthy effects on students have already been seen with the implementation of PBL in the microelectronics track

Students under the track were highly enthusiastic in the design, development and simulation a working microelectronics system design. Though the EDA tools used were not the high-end type, there were noticeable increased level of interest to use EDA tools as part of design, testing and synthesis. Another more subtle outcome was the development of the students "generic "skills in terms of organizational communication and teamwork. With the PBL sessions, students were able to organize, formulate and communicate themselves better. Strong and confident showing during the final group presentation attest to this positive development. The exposure of the students in this field also raised the level of awareness and quality of undergraduate final year projects.

Issues of maintaining competent teaching staff can be address by collaborating with industry as well as with DOST or other Universities for training and immersion. Attendance to seminars and training and conferences will likewise update the track to the trends in the industry. Funding maybe limited for the department to secure EDA tools and equipment but industry and government funding agencies maybe tap to overcome this problem.

The outcomes of the current implementation of the new mode of learning had been positive but there are still areas where improvements can be made. The University should enact enhancements to promote more student-centered learning environments. The adoption of active learningpedagogy and problem-based learning augurs wellfor Batangas State University to consistently produce quality graduate

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