Improving Digital Electronics Education with FPGA Technology, PBL and Micro Learning Methods

A Case Study from FPGA Based Digital Electronics Education Project (FPGA_b_DEEP)

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Abstract— **In this study, an ongoing Project named FPGA Based Digital Electronics Education (FPGA_b_DEEP) is introduced and the advantages of FPGA(Field Programmable Gate Arrays) technology which brought to digital design area are dealt with by using a case study. The Project aims to develop instructive and attractive examples to teach Digital Electronics efficiently and faster. In addition to this, PBL(Project Based Learning) method and Micro Learning method are dealt with at the study saperately. PBL method has been used partially at the Project and the studies on Micro Learning for association with the Project are going on recently.**

Keywords—FPGA, Digital Electronics, Engineering Education, PBL, Micro-learning

I. INTRODUCTION

FPGAs are widely used digital electronics design and prototype work. Their specialty of reconfiguration and free simulator program properties provide great advantage. The same advantages make them attractive at engineering education as well. Nowadays, in addition to engineering application, FPGAs are widely used as an education material by many Electronics and Computer Engineering Departments at universities in all over the world. Their use in engineering education dates back to 1993, but the studies made at that years are very limited. Andreas Koch, Ulrich Golze from Technical University Braunschweig, Germany[1], Li Y, Chu W, from University of Aizu, Japan[2] and Michael A. Soderstrand from University of California, USA[3] are some of them. While increasing the similar studies at the following years[4-7], some researchers began to combined FPGA technology with PBL (Project Based learning) at engineering education studies [8-12].

In this study, a project named FPGA based Digital Electronics Education Project (FPGA_b_DEEP) is introduced and the last special example developed under the project is dealt with. The project was initiated at 2008 and its aim is to develop instructive and attractive examples to teach Digital Electronics topics efficiently and faster. Some large examples from instructive and attractive example series have been published as case studies from the project [13-14]. While completing these examples, project team benefited from PBL (Project Based learning). One of the aims of the PBL is to divide projects into proper steps in order to better understanding and suitability for team studies. In the same way, the special (instructive and attractive) examples under FPGA_b_DEEP are divided into the small sub-blocks and these blocks constitute steps from basic to complex. Nowadays, the project team aims to benefit not only from the PBL but also from Micro learning. Micro learning deals with relatively small learning units and short-term learning activities.

It is important for FPGA_b_DEEP to be able to add large examples into the digital electronics course plans by split them into the small sub blocks, but it is not enough. Each sub-block must address certain topic of digital electronics course and these blocks must be formed in term of education. To reach this aim, Micro learning seems the better education method.

In this case study, a new example is developed to teach differences between combinational logic and sequential logic. The example is associated with an imaginary factory control unit in order to use all components taught at the course. This example is developed as two-stage example. At first stage, the factory control unit is designed as a combinational circuit then the same control unit is transformed to a sequential circuit. At the previous examples of the project such as Clock-calendar, Calculator, A/C converter, it was aimed to review the course topics while completing some large examples include lots of components. Unlike to the previous examples, this example is developed as a class work to complete at course hours.

The details about developed example are explained at chapter two. Associating the example with the PBL is introduced at chapter three and micro learning studies about sub-blocks are introduced at chapter three. Contribution of FPGA technology, PBL and micro learning on Digital Electronics Education is discussed at conclusion part.

II. DEVELOPING THE EXAMPLE NAMED FACTORY CONTROL UNIT

Using FPGA technology in digital electronic lectures with advanced and complex examples assured a better learning curve for the students. Due to this development the need for new improved examples and the need of modifying the curriculum according to these examples are raised. FPGA based digital electronic education eased lecturing and creating and finalizing in-class workshop projects.

This example which is treated as a case study, it was developed to use in the transition state from combinational design to sequential design given on to in-class projects. The focus of the example is to create a combinational circuit by using as much components as possible which was taught in the lectures and then converting this circuit in to a sequential one.

The most difficult part of creating the example is to use all components together. Because in real world applications using all components on the same circuit is not needed or occurs very rarely. In the example, it is explained that there are 8 chemical tanks to be controlled in the factory, they are desired to control the fluid variation in the tanks in control rooms and provide necessary information to operators. The presentation of the created example to the student was prepared as follows.

8 chemical tanks in a factory stand 300m away from the control room. The fluid levels of these tanks are measured by 8 level sensors. In the tanks, the output signal of the sensor which is closer to the fluid level goes 1(first). The number of cables that carry the level information to the control room should be kept minimum. Two 7-segment displays are used inside of control room. One is for tank number and the other is for tank liquid level. Identical displays will be in operators' room. The level information from the tanks will be updated in every 5 seconds. There will be an aural warning in both operators' and control rooms in case of the level information of a particular tank is in its highest point.

The students are supposed to think to use one encoder to encode 8-bit sensor outputs with 3 bits and to use multiplexer to get tank level information sequentially. The students are also supposed to think to use comparators for detecting the tanks with the level reached to its maximum, and to use decoder to deliver the information to tank's location in case of a danger. A counter is needed to get tank level information to the control room in every 5 seconds. Adding the counter, even it is a sequential design thing, to the combinational design is to spice up the example.

In sequential design part, students are asked to add clock inputs to the components. In addition to this, they are asked to monitor the last 3 tanks information at the same time by using shift registers and to keep all the last 24-hour-information of the tanks on a RAM.

III. ASSOCIATING THE EXAMPLE PBL

In PBL (Project Based Learning), method, several types of methods are used such as; accurate planning, inspiring interest by supporting lectures with using social activities , avoiding monotony. But in digital electronic lectures, PBL is widely used to split the whole projects or subjects into the most efficient pieces, and to locate these pieces to the most favorable place in the curriculum.

In this example which is considerably small, it is intended to finalize the example at the same time of the finalizing of the lecturing at certain level hence enhancing the students' motivation as well as comprehensibility. For this, benefited from PBL logic, this example is studied to split into the most efficient sub blocks, and associate these blocks with the most favorable place in the curriculum of Digital Elecrtronics course at the Turgut Ozal university.

The splitting process of the example can be seen at table-1. The subjects of the part 1are not related to the project but it is supplied to the plan because it has to be told before the project. Related figures (Figure 1a and 1b) are presented in the appendix.

Table-1: The splitting process of the Factory control example

Part 1 (1 week)	Introduction to digital electronics, basic logic gates and the components formed by combining them.
Part 2 (3 weeks)	Designing the combinational components and adding them to the FPGA simulator library.
Part 3 (1 week)	Combining components and finalizing the combinational design phase of the developed example.
Part 4 (3 weeks)	Designing sequential design components and adding them to the library.
Part 5 (2 weeks)	Adding clock inputs to the components which are developed as sequential design components and forming the sequential phase of the example by adding sequential design components to the circuit.

IV. ASSOCIATING THE EXAMPLE WITH MICRO LEARNING METHOD FOR FUTURE STUDIES

After dealing with splitting the example into the most efficient pieces (sub-blocks), and locating these pieces to the most favorable week in the curriculum with the help of PBL method, creating the modules for each part and making modules productive in the sense of education, is studied in the scope of Micro Learning method.

Table-2: Micro Learning Modules under Parts

Part 1 Modules	a) Encoder, b) decoder, c) multiplexer, d) demultiplexer, e) comparator
Part 2 Modules	a) Tank encoders b) multiplexer and counter c) control and operators' room d) comparator and decoder
Part 3 Modules	a) FFs and adding clock inputs to the combinational design modules b) counter c) Shift register d)RAM
Part 4 Modules	a) Control room shift register b) Control room RAM

In the micro learning studies, it is desired to define; subject to be learned, learning period and enough number of questions to test learning for each module. These all processes suit the FPGA based digital electronic education, but in the modules there are design (graphic design or coding), simulation and interpreting the simulation results instead of learning by reading thus module completing periods may be longer than the normal applications. Micro Learning Modules created for each part are presented in Table-2

V. CONCLUSION

It is aimed, in this study, to prepare a case study by developing a special example for digital electronics lecturers about how to impove digital electronics courses by using FPGA technology, PBL and Micro Learning. The study focuses on example development rather than testing an educational method performance on students. But still some of the observations about students were included.

1) When special large examples are divided to stages and prepared to provide the use of some components, as presented in this study, positive effects of these examples were seen clearly on the students / new designers. They are 44 second class students at Turgut Ozal University Electricity and Electronics department (2012 autumn period). New designers are 8 graduate students who use FPGAs at advanced Digital Design -1 course (2013 spring period).

2) By the help of these large examples, students can get the chance to repeat and combine the subjects that they learned stage by stage. It was also seen that these examples have psychological positive effects on the students. These effects are proved by the students those who spent a lot of time to study even out of the class.

3) The fact that students are able to make their own designs gives them self- confidence and motivation.

Using large and complex examples at the Digital Electronics courses as a result of the FPGA technology is a clear advantage, but this advantage brings a disadvantage which can be overcome. It appears as the difficulty of settling the curriculum. PBL method is preferred as a solution at the FPGA_b_DEEP. The feedbacks getting from students confirm this.

There are no feedbacks from students related to Micro Learning method at this study but project team found that this method is also suitable for FPGA based Digital Electronics Education.

In FPGA based Digital Electronics Education Project (FPGA_b_DEEP), primarily digital electronic education is aimed, therefore graphic design is preferred.

One more result obtaining from this study is that lecturers also can complete a project in front of student to make the course more attractive and instructive.

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APENDIX

Figure 1a: A design example for a factory control unite (after converting the combinational design to sequential design)

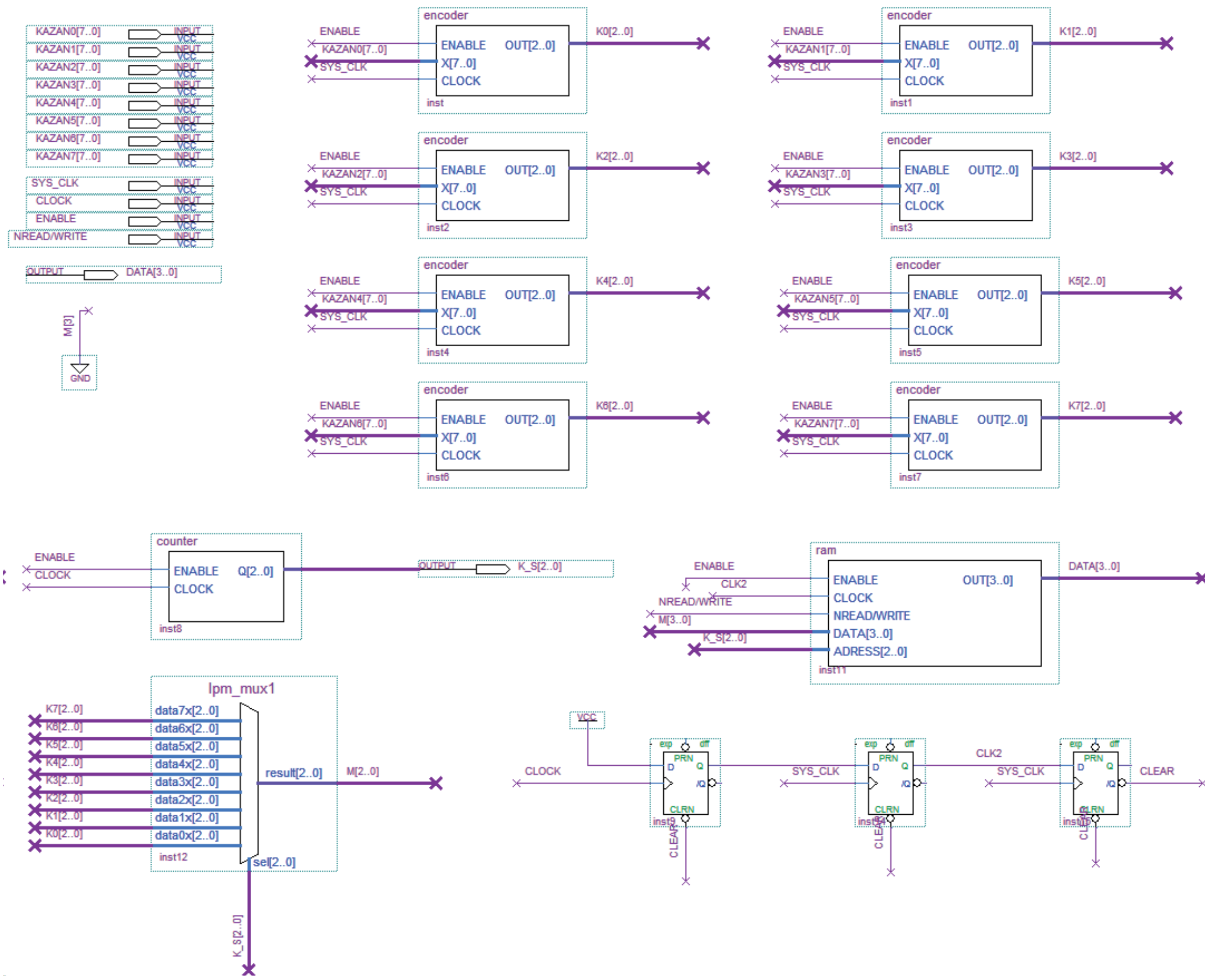

Figure 1b: A design example for a factory control unite