Abstract – Traditional methods such as exams, projects and labs can assess student’s understanding of concepts in a digital logic design course. However, there is still a need for innovative instructional pedagogy, so that the material presented is more coherent and learning outcomes are improved. The goal of this work is to implement a student research project that contributes to rapid feedback and a well constructed body of knowledge, thus improving learning outcomes. The project requires students to work in teams and prepare a 10-page research paper and an oral presentation on a topic on digital logic design. We also discuss some of the results that we have gathered in the last 3 years of teaching the digital logic design course.

Index Terms – Logic circuits design course, student research projects, interactive teaching pedagogy.

INTRODUCTION

Research suggests that with rote learning, students can lose the information gained within six to eight weeks [1]. Furthermore, there are many factors that make teaching logic circuits and microprocessors design to computer science students difficult. Some of these factors involve dealing with students who:

- are learning binary numbers, logic, and logic design for the first time,
- are facing a new technology and environment,
- are facing a new work ethic,
- have differing student backgrounds and abilities.

Teaching this course opens many challenges to instructors. There is an immediate need for instructors to introduce innovative instructional pedagogy in order to increase feedback and increase retention times. By dealing with the many problems and difficulties discussed in literature, our concern is how to improve and enhance learning outcomes for students who complete the digital logic design course at Georgia Southern University. For this, besides using the traditional teaching methodology of tests, quizzes, labs, prepared lessons and home work, we have designed a student research project. This project requires students to work in teams and prepare a report on a topic related to the material covered in class. After 2/3 of the material is covered in class, students have one week to choose a topic related to concepts discussed in the digital logic design course. They are required to pick a topic of interest related to the course and perform research in the library, on the Internet and using any other available resource. The topic might be a simple design such as the circuit for a keyless entry system, circuits for arithmetic operations, or more complicated circuits such as simulation of a circuit for elevators, alarm clocks etc. During the second week, students are asked to prepare a one-page abstract of their project. Then in the following week they prepare a paper of about 10 pages in length. Finally they have to present their work during the next class meeting. The guidelines for writing the paper are given to students in advance and are shown below:

- **Introduction Section** - General background about the paper topic, as well as the structure of it are explained here.
- **Technical Section** - The techniques used in the selected topic are presented in this section.
- **Summary Section** – This section is used to summarize the topic chosen. It also includes some conclusions or observations done by students.
- **Reference Section** – This section includes a full list of all sources used.

Students are required to follow these guidelines; however they also can extend the guidelines or introduce new sections depending on the topic of their presentation. The results obtained so far using this method have been promising.

RESULTS AND DISCUSSIONS

Student research projects integrate authentic real world scenarios into the classroom. Some of the basic ideas in this process are to give students the responsibility for defining their learning objectives and experience the planning necessary to solve problem(s) and to encourage collaborative learning among teams. This learning method better reinforces learned concepts. Since students come up with their own original ideas on designing the circuit and use the knowledge obtained during the course, the material presented in the course becomes more coherent and this contributes to the students having a well-constructed body of knowledge.

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Measuring successful outcomes of the learning process is an important issue. Instructors have considered the following questions important for evaluating success.

**What changes in the teaching process can be observed that enhance learning?**

Teaching logic design courses in the CS curriculum poses some special challenges. The main one is that students are faced for the first time with difficult concepts and they will “get by” without working with and experiencing real world applications. The course must be refined and organized to provide these opportunities.

Research shows that grade point average is one of the best indicators of success in a course. Table I summarizes the GPA class average for courses offered since fall 2002. As shown in this table, student GPA increases from fall 2002 to spring 2005.

<table>
<thead>
<tr>
<th>Term</th>
<th>Fall 2002</th>
<th>Fall 2003</th>
<th>Fall 2004</th>
<th>Spring 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Students</td>
<td>18</td>
<td>18</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Average GPA</td>
<td>2.67</td>
<td>2.9</td>
<td>3.2</td>
<td>3.2</td>
</tr>
</tbody>
</table>

**How do students use knowledge and complex reasoning compared to the recall of low-level information?**

We consider two aspects. One is the interaction between students and their instructor, and the other is the breadth and depth provided by requiring real world applications to be researched and presented by students. In order to succeed and reach the first objective, instructors must take a genuine interest and be concerned about their students. This interest starts with discussions and other interactions with students. Having extra office hours for students allows them to come and present their progress and express their interests. Furthermore, to better measure improvement, the change in average GPA should also be accompanied with an average degree of difficulty assigned to the projects. In fall 2002 there were many papers covering microprocessors and their history. These papers had a lack of breadth since they involved mostly the evolution of microprocessors and they did not mention any technical specifications. In fall 2003 there was a broader coverage of important topics, including those on arithmetic circuits. These circuits were designed and simulated by students. In Fall 2004 there were even more interesting topics including those on “Printable Circuits”, “Gallium Arsenide Chips”, “Nanotechnology” etc. There were also presentations on student designed circuits such as “Home Entry Keypad”, “Alarm Clock”, “Assembly Programming”, etc. Students designed and simulated these circuits using Altera’s software tools. In spring 2005 topics included “Cell Microprocessors”, “X-box Mod Chips”, “Arithmetic Operation Circuits”, etc. Again most of the designs were simulated in the classroom. Student interest and the range of topics have increased over time. The results gathered so far are promising and students show they have a better understanding of core concepts.

**REFERENCES**


